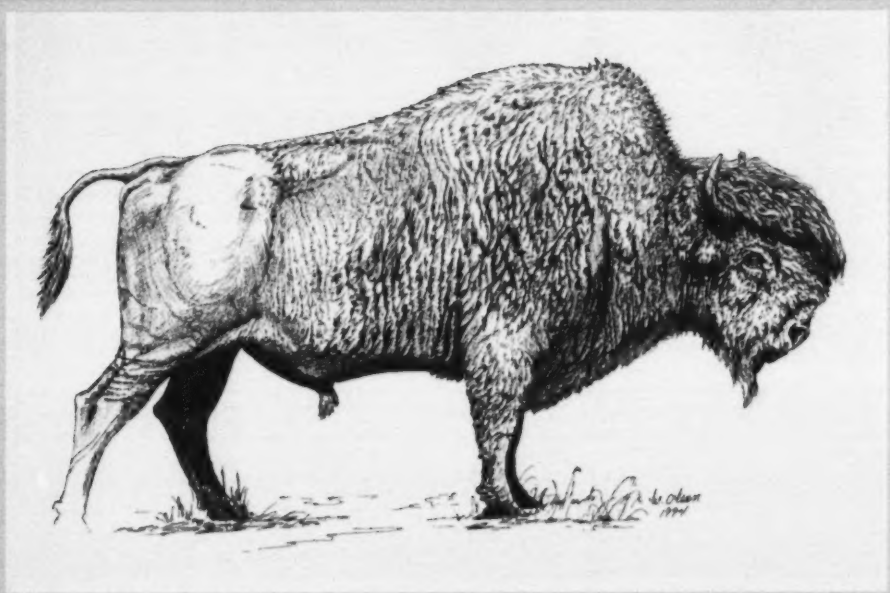
Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Wood Bison (*Bison bison athabascae*) in Canada

Wood Bison



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For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

Cover illustration: graciously provided by Wes Olson.

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[1] http://sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Wood Bison and has prepared this recovery strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Government of Alberta, the Government of British Columbia, the Government of Manitoba, the Government of the Northwest Territories, the Tłı̨chǫ Government, the Wek'èezhìı Renewable Resource Board, the Government of Yukon, and the Yukon Fish and Wildlife Management Board, and any others as per section 39(1) of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment and Climate Change Canada and the Parks Canada Agency or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of Wood Bison and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment and Climate Change Canada and the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

In the case of critical habitat identified for terrestrial species including migratory birds SARA requires that critical habitat identified in a federally protected area[3] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss.

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[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

[3] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

If the critical habitat for a migratory bird is not within a federal protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgements

This recovery strategy was drafted by Greg Wilson, Hal Reynolds, Tara Fulton, Lea Craig-Moore, and Renee Franken (Environment and Climate Change Canada (ECCC)). It was prepared based on information updated from the 2001 Wood Bison Recovery Plan, and in consultation with members of the national Wood Bison Recovery Team (WBRT) whose members included Terry Armstrong (Northwest Territories (NT) Department of Environment and Natural Resources), Matt Besko (Alberta (AB) Environment and Parks, Fish and Wildlife Division), Norm Cool (Parks Canada Agency (PCA)), Cormack Gates (University of Calgary), Thomas Jung (Yukon (YT) Department of Environment), Stuart Macmillan (PCA), John Nishi (ex-officio member), Hal Reynolds (ECCC), Helen Schwantje (British Columbia (BC) Ministry of Environment), Todd Shury (PCA), Bob Stephenson (Alaska Department of Fish and Game), Bill Watkins (Manitoba (MB) Conservation), and Greg Wilson (ECCC). Alternate members consisted of Brett Elkin (NT Department of Environment and Natural Resources), Craig Gardner (Alaska Department of Fish and Game), George Hamilton (AB Environment and Parks, Fish and Wildlife Division), Archie Handel (PCA), Brian Joynt (MB Conservation), Rhona Kindopp (PCA), and Michelle Oakley (YT Department of Environment). All members of the WBRT are thanked for input and for reviewing and contributing to this recovery strategy. Dawn Andrews (PCA) Nic Larter, Rob Gau, and David Dewar (NT Department of Environment and Natural Resources), Brian Hagglund (MB Conservation), and Conrad Thiessen and Mike Rowe (BC Ministry of Environment) are thanked for providing information for the recovery strategy. Special thanks go to Wes Olson for the use of the cover illustration and the Wood Bison photograph. Thank you to Gillian Turney and Jeff Harder (ECCC) for preparing maps. Dave Duncan, Medea Curteanu, Keri McFarlane, Emily Jenkins, Amy Ganton, Dawn Andrews, Donna Bigelow, Shannon Stotyn, Saleem Dar, Michael Svoboda, and Stephen Hureau (ECCC) are thanked for their review and/or consultation efforts. The Wek'èezhìi Renewable Resources Board;Sue Cotterill, Joann Skilnick, and Natalka Melnycky (AB Environment and Parks); Conrad Thiessen and Gerald Kuzyk (BC Ministry of Environment); Brian Joynt (MB Conservation); Thomas Jung, Todd Powell, and the Yukon Wood Bison Technical Team (YT Department of the Environment); Terry Armstrong, Joanna Wilson, Scott Taylor and Brett Elkin (Government of NT); Lana Cortese, Stuart Macmillan, Shelley Pruss, Laurie Wein, and Marie-Josee Laberge (PCA) and numerous anonymous reviewers are thanked for their reviews and comments.

Environment and Climate Change Canada (ECCC) thanks the Indigenous communities surrounding the range of Wood Bison who participated in the development of this document through their feedback and the time and knowledge that they shared with ECCC to inform this document. Specifically, ECCC thanks (in no particular order) Fort McMurray Métis Local 1935, Fort Chipewyan First Nation, Fort Chipewyan Métis Local 125, Mikisew Cree First Nation, Fort McKay First Nation, Beaver First Nation, Little Red River Cree Nation, Deninu K'ue First Nation, West Point First Nation, Acho Dene Koe First Nation, Dene Tha' First Nation, Tallcree First Nation, Métis Nation of Alberta Region 6, Métis Nation of Alberta Region 5, Kluane First Nation, Selkirk First Nation, Champagne and Aishihik First Nations, Métis Nation of BC, Fort Nelson First Nation, TłįchǫGovernment, Deh Gah Got'ie First Nation, Salt River First Nation, Smith's Landing First Nation, Katl'odeeche First Nation, Doig River First Nation, Kaska Dena Council, Selkirk First Nation, and the community members of Behchokǫand Fort

Providence. The Indigenous traditional and community knowledge that was shared may also be used to support the development of action plans and future identification of critical habitat, where consent for such use is granted. ECCC appreciates that so many Indigenous peoples were willing to share their knowledge and experiences to help with the recovery of this species.

Executive Summary

Historically, Wood Bison (*Bison bison athabascae*) range extended throughout the boreal forest of Alberta, British Columbia, Saskatchewan, and much of the Northwest Territories, Yukon, and Alaska. During the early 1800s, Wood Bison numbers were estimated at 168,000 animals, but by the late 1800s only a few hundred animals remained. In 1978, Wood Bison were designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Because of an active recovery program and increased numbers, COSEWIC downlisted Wood Bison to Threatened in 1988. Wood Bison were listed as Threatened under the *Species at Risk Act* (SARA) in 2003. Wood Bison were re-examined by COSEWIC and assessed as Special Concern in November 2013, as numbers increased to nearly 10,000 animals. As of 2018, the Minister of Environment and Climate Change has not formed a recommendation regarding the downlisting of Wood Bison to Special Concern under SARA. Estimates made in 2010-2015 show ~8,587 free-ranging Wood Bison in Canada, although approximately half of these animals (N=4,224) reside in populations affected by the introduced cattle diseases, bovine tuberculosis and brucellosis. There are also ~4,363 Wood Bison in nine free-ranging, disease-free local populations plus 300 individuals in one public, captive, disease-free local population managed for conservation.

A lack of public acceptance for some reintroduced herds and drowning have been identified as limiting factors for Wood Bison. The greatest threat to Wood Bison recovery is the presence of the exotic bovine diseases brucellosis and tuberculosis on the landscape, and the resultant management actions taken. Other threats include: agriculture; energy production and mining; transportation and service corridors; hunting and collecting; logging and wood harvesting; human intrusions and disturbance; fires and fire suppression; dams and water management; invasive thistle species; severe anthrax outbreaks; increased predation; hybridization with Plains Bison, domestic bison, or cattle; pollution; climate change and severe weather; and loss of genetic diversity.

The short-term population and distribution objective is to maintain the disease-free status (free of bovine tuberculosis and brucellosis), population size and range of all disease-free Wood Bison local populations within the original range of Wood Bison in Canada. If future work shows that some of these local populations are not self-sustaining, population size and/or range size should be increased so that self-sustaining status can be attained. The maintenance of genetic diversity in diseased and disease-free local populations is also a critical component of Wood Bison recovery. This is especially true for the Wood Buffalo National Park and surrounding local populations, which retain the greatest level of genetic diversity as they are naturally established populations, compared to those established by human-mediated translocation.

The long-term population and distribution objective is to ensure the existence of at least five disease-free, genetically diverse, connected, self-sustaining, free-ranging local populations distributed throughout their original Canadian range, with a minimum size for each local population of 1,000 animals. The long-term population and distribution objective is meant to build on the short-term population and distribution objective, not replace it. Population and distribution objectives are not achieved until local population levels can sustain traditional

Indigenous harvesting activities, consistent with existing Aboriginal and Treaty rights of Aboriginal peoples in Canada.

Broad strategies to be taken to address the threats to the survival and recovery of the species are presented in the section on Strategic Direction for Recovery (Section 6.2). Insufficient information was available to Environment and Climate Change Canada to identify Wood Bison critical habitat at the time this recovery strategy was prepared. A schedule of studies to identify critical habitat is outlined in Section 7.2.

One or more action plans for Wood Bison will be completed by 2022.

Recovery Feasibility Summary

Based on the following four criteria that Environment and Climate Change Canada uses to establish recovery feasibility, recovery of Wood Bison has been deemed technically and biologically feasible.

1. Are individuals capable of reproduction available now or in the foreseeable future to sustain the population or improve its abundance?

Yes. While the current number of mature Wood Bison is unknown, most of the ~8,587 free-ranging Wood Bison are capable of successful reproduction to increase population growth rate or abundance. Most Wood Bison local populations are stable.

2. Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?

Yes. There is sufficient suitable habitat available to support Wood Bison recovery. Additional habitat could be made available to Wood Bison by habitat modification and management. However, there are presently large areas within the original range of Wood Bison where reintroduction or expansion of Wood Bison is not desirable due to the risk of the transmission of bovine brucellosis and tuberculosis to disease-free Wood Bison herds, and concern from the public about the risk of the spread of these diseases to ranched animals.

3. Can the primary threats to the species or its habitat be avoided or mitigated through recovery actions?

Yes. Although a number of factors continue to threaten Wood Bison, there are several strategies to avoid or mitigate these threats through recovery actions. Various actions are available or are being developed to eliminate the threat of the transmission of bovine tuberculosis and brucellosis to disease-free local populations. Public education and the opportunity for collaborative management should also increase public acceptance of having Wood Bison on the landscape. There are other primary threats to Wood Bison recovery that can be found in the Threats section (4.0).

4. Do the necessary recovery techniques to achieve the population and distribution objectives exist, or can they be developed in a reasonable timeframe?

Yes. Previous reintroductions to a number of areas show that recovery techniques for Wood Bison can be successful. Achieving the long-term population and distribution objective of disease-free Wood Bison local populations throughout their original Canadian range will require that techniques to eliminate the threat of the transmission of bovine brucellosis and tuberculosis to disease-free local populations be developed, as the long-term success of current disease management efforts is unlikely given the likelihood of diseased animals moving into areas populated by disease-free local populations (APFRAN 1999, Gates et al. 2001a). Existing and novel techniques (for example, artificial reproductive technology) may need to be used to ensure that the loss of diversity from Wood Bison populations is limited.

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1 COSEWIC* Species Assessment Information[4]

Date of Assessment: November 2013

Common name: Wood Bison

Scientific name: *Bison bison athabascae*

COSEWIC Status: Special Concern

Reason for designation: This bison only occurs in the wild in Canada. There are currently 5,136 to 7,172 mature individuals in nine isolated wild subpopulations. The population has increased since 1987, mostly due to the establishment of new wild subpopulations within the original range. About 60% of the overall population is included in Wood Buffalo National Park and surrounding areas, and is affected by two cattle diseases, bovine brucellosis and tuberculosis. Two wild subpopulations have recently experienced significant mortality events demonstrating the inherent vulnerability of small isolated populations. The Mackenzie herd decreased by 53% due to an outbreak of anthrax and the Hay-Zama decreased by 20% due to starvation during a severe winter. Further increases to the population size or the addition of new wild subpopulations is not likely, as recovery is constrained by fragmented or unsuitable habitat, road mortality, disease management associated with livestock and commercial bison operations, and disease outbreaks.

Canadian Occurrence: BC, AB, YT, NT, MB.

COSEWIC Status History: Designated Endangered in April 1978. Status re-examined and designated Threatened in April 1988 and May 2000. Status re-examined and designated Special Concern in November 2013.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

Environment and Climate Change Canada has prepared this Recovery Strategy for Wood Bison, as they are currently listed as Threatened on Schedule 1 of the *Species at Risk Act* (SARA). The recommendation made by COSEWIC to downlist the species to Special Concern is presently being evaluated by Environment and Climate Change Canada. If the SARA status is changed to Special Concern, a Management Plan will be produced.

2 Species Status Information

In Canada, the Wood Bison (*Bison bison athabascae*) is listed as Threatened on Schedule 1 in SARA. In British Columbia, Wood Bison are on the "Red List" of indigenous species or subspecies that are Extirpated, Endangered, or Threatened in British Columbia (B.C. Conservation Data Centre 2012). In 2004, Alberta's Endangered Species Conservation

[4] The COSEWIC Status Assessment Information provided is from the 2013 Assessment and Status Report on the Plains Bison and the Wood Bison and does not necessarily reflect the most current information available.

Committee recommended to the Minister of Sustainable Resource Development to list all free-ranging bison as "endangered" in Alberta (Fish and Wildlife Division 2008). Currently, the only listed bison in Alberta occur within the Bison Protection Area in northwestern Alberta, where they are considered "endangered" under Alberta's *Wildlife Act*, and in the area surrounding the Ronald Lake local population, where they are considered a "subject animal" under the *Wildlife Act*, restricting the non-Indigenous hunt. In the Northwest Territories, the species has been assessed as "threatened" (SARC 2016) and is under consideration for listing under the *Species at Risk (NWT) Act*. Wood Bison are not listed as "specially protected" under the Yukon *Wildlife Act*, but are recognized as being listed as Threatened by COSEWIC (Government of Yukon 2012a).

The NatureServe (2015) subnational ranks are listed in Table 1. NatureServe (2015) has ranked Wood Bison with a Canadian national status of N2N3 (imperiled to vulnerable) and a global status of T2 (imperiled).

Table 1. NatureServe (2015) provincial and territorial ranks

Province	NatureServe Subnational Rank
British Columbia (BC)	S2 – Imperiled
Alberta (AB)	S1 – Critically Imperiled
Saskatchewan (SK)	SX – Presumed Extinct
Manitoba (MB)	SNA – Not Applicable
Northwest Territories (NT)	S2 – Imperiled
Yukon (YT)	S2S3 – Imperiled to Vulnerable

All of the species' global distribution occurs in Canada except for one free-ranging population in Alaska, U.S., that was released into the wild in 2015. Wood Bison were downlisted in the U.S. under the U.S. *Endangered Species Act* from Endangered to Threatened in 2012. The U.S. listing was based on the number and status of Wood Bison in Canada. In 2008, the International Union for the Conservation of Nature (IUCN) uplisted Wood Bison as a species globally from "Lower Risk – conservation dependent" to "Near Threatened" (Gates and Aune 2008). In 1997, the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) downlisted Wood Bison from Appendix I to Appendix II (CITES 2006). Wood Bison were removed from Appendix II in 2017.

3 Species Information

3.1 Species Description

Wood Bison are the largest native terrestrial mammal in North America. They have a large triangular head, large shoulders with a high hump, and long dark brown and black hair around their head and neck (Figure 1; van Zyll de Jong et al. 1995). Males possess short, thick, black horns that end in an upward curve, while females possess thinner, more curved horns (Fuller 1962).

Figure 1- Male Wood Bison © Wes Olson.

Most experts recognise Wood Bison as a subspecies[5] of the North American bison (*Bison bison*; Cook and Muir 1984, van Zyll de Jong 1986; for review see COSEWIC 2013). It is distinguished from the Plains Bison (*Bison bison bison*) subspecies by the Wood Bison's following characteristics: larger size and darker colour; absence of chap hair on the front legs; less distinct, but darker cape of the shoulders, hump, and neck region; longer and more heavily haired tail; and shorter and less dense hair on the top of the head, around the horns, and beard (see Reynolds et al. 2003 for a review).

Wood Bison are culturally important to many Indigenous peoples (Appendix 1), and are known by many names in different Indigenous cultures (Table 2 lists some examples). Gathering for the annual bison hunt (of Plains or Wood Bison) was a significant event for the Métis people of western Canada and is implicated in the formation of the Métis government (Appendix 1). Wood Bison are also known by many Indigenous and non-Indigenous peoples as buffalo.

Table 2. Examples of names for Wood Bison

Name for Wood Bison	Cultural Source
Dechįtah goegié	South Slavey
Dechen yághe ejere, thachin ya n'jere	Dené sųłiné
Dachan tat gwi'aak'ii	Teetł'it Gwich'in
Aak'ii, Dachantat aak'ii	Gwichya Gwich'in
Łek'aye, łuk'aye, kedä-cho', ejedi	Kaska Dene
Ejuda	Slavey
Tl'oo tat aak'ii, dachan tat aak'ii, akki chashuur, nin shuurchoh, nin daa ha-an	Van Tat Gwich'in
Sakâw mostos	Mikisew Cree
Sagow mustoos	Fort McKay First Nation (Cree)
Edur-ay-cho-k	Fort McKay First Nation (Dene)
Keemoiwu hak ui	Beaver First Nation

3.2 Species Population and Distribution

Historical distribution and abundance

The original distribution of Wood Bison occurred throughout the boreal forest of northwestern North America, including parts of the northern regions of Alberta, British Columbia, Saskatchewan, and much of the Northwest Territories, Yukon, and Alaska (Figure 2; van Zyll de Jong 1986, Stephenson et al. 2001). The historic Plains Bison range was to the south of that of Wood Bison. However, Plains and Wood Bison may have intermingled where their distributions overlapped during winter in the aspen parkland of what is now central Alberta and British Columbia.

Wood Bison were never as numerous as Plains Bison. Soper (1941) estimated there were once 168,000 Wood Bison. Like the Plains Bison, Wood Bison were nearly eliminated during the late

[5] Subspecies refers to a group of natural populations capable of interbreeding but differing with respect to gene pool characteristics. They are often isolated geographically from other such groups within a biological species.

1800s. Over-hunting, changes in the distribution of habitat, and severe winters may have played a role in the decline (Soper 1941, Fuller 1962, Stephenson et al. 2001). By 1896, Wood Bison had declined to fewer than 250 animals (Soper 1941). By the 1920s, numbers had slowly increased to ~1,500 animals (Carbyn et al. 1993) and in 1922, Wood Buffalo National Park was created to protect habitat and prevent extinction of the Wood Bison (Soper 1941).

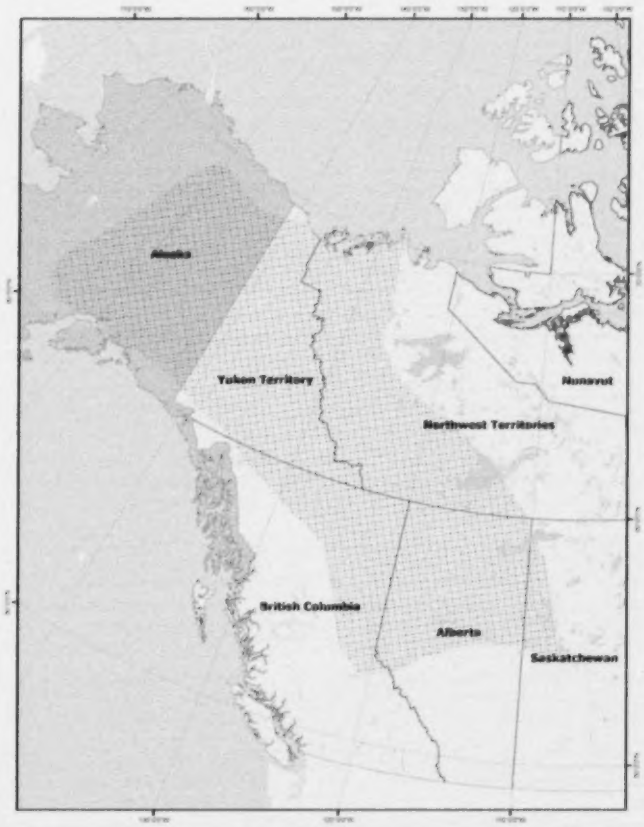

Figure 2– Original distribution of Wood Bison during the last 5,000 years (stippled). Based on available zooarcheological and paleontological evidence and oral and written accounts (adapted from Stephenson et al. 2001).

From 1925 to 1928, 6,673 Plains Bison were transferred from Buffalo National Park[6], Wainwright, Alberta, to Wood Buffalo National Park, an event that was contested at the time (Harper 1925, Howell 1925, Saunders 1925). This translocation is believed responsible for the introduction of two cattle diseases, bovine tuberculosis (*Mycobacterium bovis*) and bovine brucellosis (*Brucella abortus*) to Wood Buffalo National Park (see Appendix 2 for a summary of disease management in Wood Buffalo National Park). By 1934, there were approximately 12,000 bison in Wood Buffalo National Park (Soper 1941), in part due to the introduction of Plains Bison that mixed and interbred with the resident Wood Bison.

[6] Buffalo National Park was created in 1909 to protect bison. It was closed in 1940 and transferred to the Department of National Defence.

In 1959, isolated Wood Bison were found in northwestern Wood Buffalo National Park. Following disease testing, 16 of these animals were successfully transferred in 1963 to the newly established Mackenzie Bison Sanctuary, Northwest Territories (referred to as the Mackenzie population throughout this document), and 23 animals were transferred to Elk Island National Park, Alberta. Genetic and morphological evidence indicated that low levels of hybridization had occurred between Wood and Plains Bison in Wood Buffalo National Park prior to the founding of the Mackenzie and Elk Island National Park local populations (van Zyll de Jong 1986, Wilson and Strobeck 1999). The founding individuals of Elk Island National Park were later discovered to carry tuberculosis that was originally undetected. The transmission of this disease requires close animal contact, illustrating that these 'pure' Wood Bison individuals had already been in contact with the disease-carrying Plains Bison before they were moved to Elk Island National Park. These adults were then culled to eliminate disease from the herd and 11 disease-free calves were salvaged and hand-reared. The Elk Island National Park local population[7] and all herds derived from it are descended from these calves (Appendix 3). However, Wood Bison continue to be genetically distinct from Plains Bison and should be managed separately as a distinct subspecies (Wilson and Strobeck 1999).

Current distribution and abundance

Based on estimates made between 2010 and 2016, there are approximately 8,587 free-ranging Wood Bison in Canada: ~4,363 Wood Bison in nine free-ranging, disease-free[8] local populations, ~4,224 in three free-ranging local populations with diseases (bovine tuberculosis and brucellosis), and 300 in one captive local population maintained for conservation purposes at Elk Island National Park (Table 3, Figure 3). More detailed information about the history of these local populations can be found in Wood Bison Recovery Team (1987) status report, Gates et al. (2001a), and COSEWIC (2013). There are also an estimated 45-60 commercial herds of Wood Bison in Canada containing approximately 500-700 animals (Gates et al. 2001b). Privately-owned commercial production herds are not considered within the scope of this recovery strategy, nor are they part of recovery programs. There are also approximately 50 Wood Bison in zoos and wildlife parks in Canada, which are also not considered within the scope of this recovery strategy.

Because of gene flow (Ball et al. 2016) and the possibility for animal movement between Wentzel Lake, the Slave River Lowlands, and Wood Buffalo National Park due to their proximity to one another (Figure 3), these local populations are sometimes collectively referred to as the greater Wood Buffalo National Park metapopulation throughout this document. Two additional local populations, Wabasca and Ronald Lake, are also geographically proximate to Wood Buffalo National Park, but neither appears to routinely exchange individuals with the large neighbouring metapopulation, and both Ronald Lake and Wabasca are genetically differentiated from neighbouring local populations (Ball et al. 2016). Both Wabasca and Ronald Lake are also considered to be disease-free, further suggesting that movement is limited between these local

[7] In this recovery strategy, a local population is defined as a group of Wood Bison subject to similar factors affecting their demography and occurring in the same discrete geographic area.
[8] Disease-free refers to local populations that are not infected with bovine tuberculosis or brucellosis. Anthrax is not included because, unlike the other two diseases, it was not recently introduced to bison by cattle.

populations and the Wood Buffalo National Park metapopulation. The free-ranging local populations with diseases (Slave River Lowlands, Wentzel Lake, and Wood Buffalo National Park) are important sources of genetic diversity, as they collectively represent the largest free-ranging Wood Bison population and also the most genetically diverse population (Wilson and Strobeck 1999, Wilson et al. 2005, McFarlane et al. 2006). All local populations within and around Wood Buffalo National Park (including Wabasca and Ronald Lake) represent the only location worldwide where Wood Bison have continually persisted or naturally colonized. All other extant populations derive from Wood Buffalo National Park by human-mediated translocation either directly or via Elk Island National Park (Appendix 3).

Table 3. Sizes of Wood Bison local populations

Local Population Category and Name	Province or Territory	Year of Latest Estimate	Estimated Population Size[a]
Free-Ranging, Disease-free Local Populations			
Aishihik	YT	2014	1,470 [1,306-1,684][b]
Chitek Lake	MB	2011	250-300[c]
Etthithun Lake	BC	2011	200-300[d]
Hay Zama	AB	2016	626[e]
Mackenzie	NT	2016	851±209[f]
Nahanni	NT, YT, BC	2011	431±213[g]
Nordquist/Liard	BC, YT	2010	200-250[d]
Ronald Lake[h]	AB	2013	~200[i]
Wabasca (or Wabasca/Mikkwa)[h]	AB	2010	30-40[j]
Subtotal			*4,363*
Captive, Disease-free Conservation Local Populations – Public			
Elk Island National Park	AB	2014	300[k]
Subtotal Disease-free Local Populations			**~4,663**
Free-Ranging Local Populations with Diseases			
Slave River Lowlands	NT	2016	662±175[l]
Wentzel Lake	AB	2015	199[e]
Wood Buffalo National Park	NT, AB	2014	3,363±893[m]
Subtotal Local Populations With Diseases			**~4,224**
TOTAL =			**~8,887**

[a] Where only a range of estimates is provided, the median was used to calculate subtotals and total.

[b] Jung and Egli 2014

[c] Brian Joynt, pers. comm., June 2012

[d] Daniel Lirette, pers. comm., August 2015

[e] Minimum count, Natalka Melnycky, pers. comm., April 2016

[f] Armstrong and Boulanger 2016a

[g] Nic Larter, pers. comm., September 2015

[h] Between 2011 and 2014, 24 animals from Wabasca and 73 from Ronald Lake were disease-tested and no disease-positive results were obtained. The province of Alberta currently manages these herds as disease-free, as there is a 95% probability that disease prevalence is below 5%, if it is present at all (Government of Alberta 2015). In comparison, the Wood Buffalo National Park local population has a disease prevalence of 30-40%.

[i] Government of Alberta 2013

[j] Dave Walty, pers. comm., May 2012

[k] Herd managed to this target size by Parks Canada

[l] Armstrong and Boulanger 2016b

[m] Government of Alberta 2015

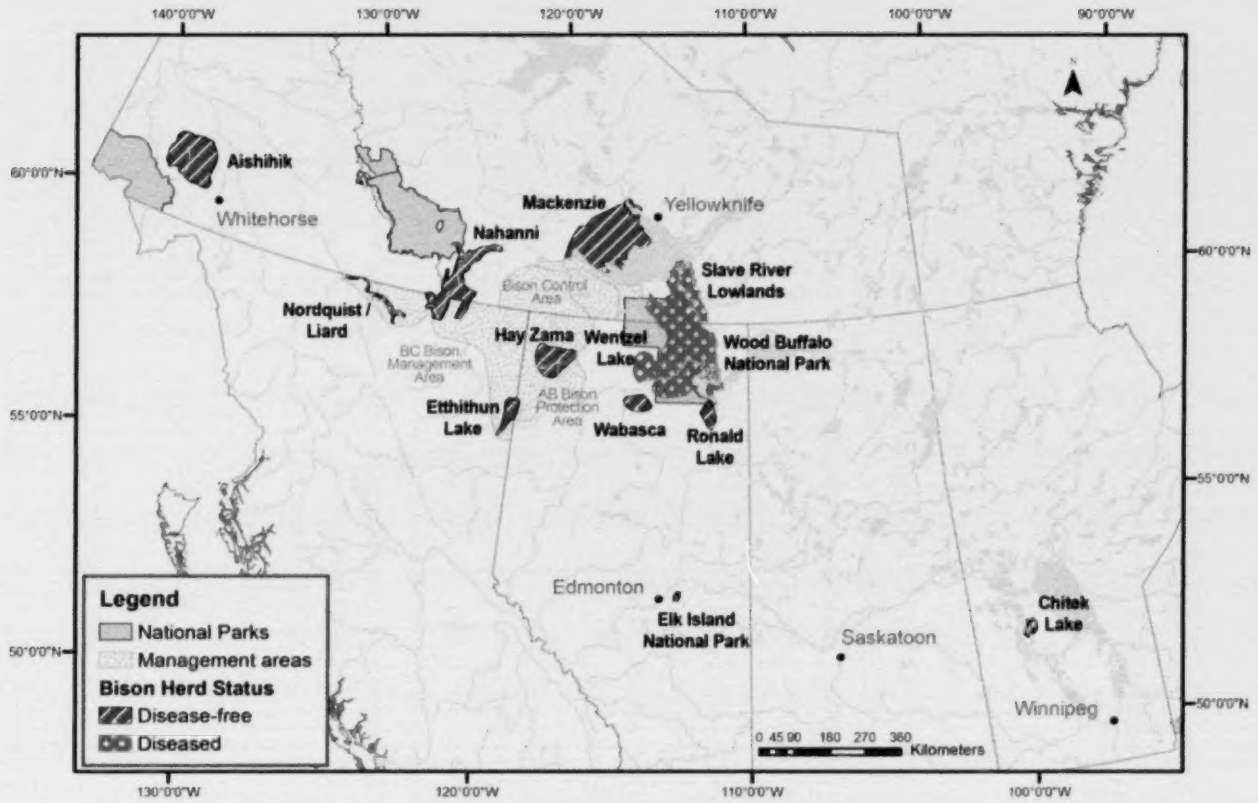

Figure 3 - Location of free-ranging Wood Bison local populations in Canada. Disease status (disease-free, or diseased) is indicated per the inset colour key legend to indicate the presence or absence of bovine brucellosis and tuberculosis. Wood Bison control and management areas in NT, BC, and AB are indicated by the light brown stippled areas. Bison on non-federal lands outside of British Columbia's Bison Management Area are not protected from hunting. Bison are not protected from unregulated hunting on non-federal lands outside the AB bison protection area, except for the area surrounding the Ronald Lake local population, where bison are considered a Subject Animal and non-Indigenous hunting is restricted under Alberta's *Wildlife Act*. Removal of bison is unregulated within the NT bison control area and the Slave River Lowlands to reduce the risk of disease transmission from the Wood Buffalo National Park area to disease-free herds. Green areas indicate National Parks.

3.3 Needs of the Wood Bison

Habitat requirements

Wood Bison are primarily grazers, relying on a variety of grasses and sedges found in meadows occurring on alkaline soils and early succession habitats (Reynolds et al. 1978, Reynolds and Hawley 1987). Wood Bison show strong seasonal changes in diet, selecting plants that yield the greatest protein (Larter and Gates 1991). Wood Bison generally tend to use wet meadows with predominantly native graminoid vegetation, such as sedges (*Carex* spp.) and grasses (*Calamagrostis* spp., *Scolochloa festucacaea*) as winter grazing habitat; meadows that contain slough sedge (*Carex atherodes*), northern reed-grass (*Calamagrostis canadensis*), and/or willow (*Salix* spp.) as summer grazing habitat; and deciduous and pine (e.g. Jack Pine, *Pinus banksiana*) forests associated with these meadows for resting, ruminating, avoiding biting flies, protection from deep snow and wind, and foraging at various time throughout the year (Reynolds et al. 1978, Larter and Gates 1991, Jung 2015, Jung et al. 2015b). Bison do not appear to have specific habitat requirements for rutting, mating, or gestation; however, female groups tend to select larger meadows during the calving season (Calef and Van Camp 1987). Grassland/sedge habitat represents 5–20% of the land area in most Wood Bison ranges, usually interspersed among tracts of coniferous and aspen (*Populus* spp.) forest, bogs, fens, and shrublands.

Limiting factors

Lack of Public Acceptance

In the greater Wood Buffalo National Park area where Wood Bison have persisted through time, the Indigenous peoples of the area generally maintain a very strong, positive, connection with the Wood Bison and are advocates for their conservation (Appendix 1). However, Wood Bison local populations have also been reintroduced to parts of their range (Appendix 3), including Etthithun Lake, Hay Zama, Aishihik, Nahanni, Nordquist/Liard and Mackenzie, to varying degrees of acceptance by local residents across time and communities. Many Indigenous communities near reintroduced herds have raised concerns about their interactions with the reintroduced animals, including trampling of plants and traplines, destruction of property, negative impacts on other valued species, and human-bison conflicts (Appendix 1). However, many Indigenous communities also noted their support of the species, and the importance of its conservation to them. For example, Clark et al. (2016) reviewed these concerns and considerations as they pertain to local perceptions toward the Aishihik population in Yukon. Greater acceptance toward reintroduced populations is often associated with greater initial consultation efforts, and the ability of local Indigenous and non-Indigenous peoples to harvest the reintroduced Wood Bison once populations are stable. Local farmers and cattle/bison ranchers are also often opposed to wild bison on the landscape, as bison can consume and trample crops and pose a threat for disease transfer to commercial animals (Section 4, IUCN threat 8.1). Without public acceptance, it can be difficult to maintain conservation efforts to ensure that Wood Bison local populations continue to occur on the landscape, limiting Wood Bison recovery. Public acceptance is also a primary consideration when determining potential locations to reintroduce Wood Bison populations and, as such, has a major impact on the range of the species. Thus, a lack of public acceptance for reintroduced populations is considered a limiting factor.

Drowning

Wood Bison use habitats that include wetlands, rivers, and open water bodies during all seasons. Some Wood Bison drown each spring because of flooding or falling through thin ice (Carbyn et al. 1993, Reynolds et al. 2003, Appendix 1). Because the Liard River bisects the Nahanni local population range and animals consistently cross the river, animal drowning may be a more regular and consistent mortality factor in this local population than elsewhere (Larter et al. 2003). Large drowning incidents involving 1,000-3,000 animals are also known to have occurred in Wood Buffalo National Park. Four such events have occurred in the last 70 years. While drowning is likely not a main limiting factor to Wood Bison in Canada, it does have implications for the survival and growth of small populations, since as a stochastic event it could reduce population size and viability.

Habitat Availability

The total amount of habitat available for Wood Bison recovery is unknown, but is not considered a key limiting factor at this time.. Further information on habitat requirements, availability and supply are necessary before this can be substantiated. However, it is possible that habitat is limiting at the local level for some populations through industrial development, which may be impacting Wood Bison population growth and connectivity. The presence of diseased bison on parts of the landscape requires a disease management strategy that constrains the ability to allow for population expansion.

4 Threats

4.1 Threat Assessment

Threats are listed in Table 4, following the IUCN – CMP Unified Classification of Direct Threats version 3.2 descriptions and threat calculator, similar to that employed in the COSEWIC (2013) assessment. While the threats are listed individually, many Indigenous communities and members of the scientific community raised concerns that the cumulative impact of these multiple threats over time remains unknown (Appendix 1).

Table 4. Threat Assessment Table

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed Threats/Comments
2	**Agriculture & aquaculture**	**Low**	**Restricted**	**Slight**	**High**	
2.1	Annual & perennial non-timber crops	Low	Restricted	Slight	High	Herd expansion limited by agriculture. This threat is inferred.
2.3	Livestock farming & ranching	Low	Restricted	Slight	Moderate	Herd expansion limited by ranching; potential for bi-directional disease transfer (Threat 8.1). This threat is inferred.
3	**Energy production & mining**	**Low**	**Large**	**Slight**	**High**	
3.1	Oil & gas drilling	Low	Large	Slight	High	Direct mortality; disturbance at or near well sites. Other impacts (road construction, worker presence, pollution) are considered elsewhere. This threat has been observed.
3.2	Mining & quarrying	Low	Small	Extreme	Moderate	The Ronald Lake herd may be significantly impacted by the mine(s) proposed within their range. Mining also occurs in YT. This threat is inferred.
4	**Transportation & service corridors**	**Low**	**Large**	**Moderate-Slight**	**High**	
4.1	Roads & railroads	Medium-Low	Large	Moderate - Slight	High	Many herds live along roads and road mortality is common in some herds. Roads also facilitate hunting, though hunting mortality is accounted for in Threat 5.1. This threat has been observed.
4.3	Shipping lanes	Low	Small	Slight	High	Barge traffic could lead to mortality for the Nahanni herd. This threat has been inferred.
5	**Biological resource use**	**Medium**	**Pervasive**	**Moderate**	**High**	
5.1	Hunting & collecting terrestrial animals	Medium	Pervasive	Moderate	High	5.1.1 Intentional Use. Indigenous Traditional use and non-Indigenous hunting. Hunting occurs both legally and illegally; unregulated hunting is a risk. 5.1.3 Persecution/Control. Although required in the short-term to prevent disease transmission, the largest threat to bison expansion across the landscape are the strong control measures taken to prevent the spread of disease from the Wood Buffalo National Park region to disease-free herds and domestic ranched animals. This threat has been observed.
5.3	Logging & wood harvesting	Unknown	Restricted	Unknown	High	Clear-cutting may create new meadows and regenerate summer habitat, but these areas do not represent good winter habitat. Logging may increase forage quantity, but not quality. This threat is inferred.

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed Threats/Comments
6	**Human intrusions & disturbance**	**Low**	**Restricted**	**Slight**	**High**	
6.3	Work & other activities	Low	Restricted	Slight	High	Industrial activities are disruptive to animals and they generally avoid both helicopters and areas where ongoing work is occurring. This threat is inferred.
7	**Natural system modifications**	**Low**	**Large**	**Slight**	**High**	
7.1	Fire & fire suppression	Low	Large	Slight	High - Moderate	Fire suppression may limit grazing and meadows for calving. Fire itself naturally acts to maintain meadow habitat preferred by Wood Bison, and prescribed burning is thought to improve bison habitat. Fires that burn too hot and too strong (often due to fire suppression over a long period or climate change) can cause direct mortality or starvation due to exclusion from a region until regrowth begins. This threat is inferred.
7.2	Dams & water management/use	Low	Large	Slight	High	The W.A.C. Bennett Dam on the Peace River, along with climate change, has resulted in hydrological changes in the Peace river system. Additional proposed dams may worsen these effects or impact other regions. This threat is observed.
8	**Invasive & other problematic species & genes**	**High-Medium**	**Large**	**Serious - Moderate**	**High**	
8.1	Invasive non-native/alien species	Medium-Low	Large	Moderate - Slight	High	Brucellosis and bovine tuberculosis are cattle-derived diseases in the Wood Buffalo National Park (WBNP) metapopulation (~50% of the species). Presence of both of these diseases appears to increase depredation by wolves. Significant population control measures are implemented outside WBNP to stop the spread of these diseases (Threat 5.1.3). (scope=Large; Severity=Slight) Invasive thistle species in Wood Buffalo National Park exclude bison from previously high quality range, as they cannot forage in these areas and avoid walking through them. (scope=Large; Severity=Slight) Reclamation seed mixes on well sites and other disturbed locations can result in the introduction and spread of non-native plant species, as can vehicle traffic. The impact of non-native plants on bison is unknown, but they can alter movement patterns by being more or less palatable to the species (scope=Large; Severity=Slight). This threat is inferred.

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed Threats/Comments
8.2	Problematic native species	High-Low	Pervasive	Serious - Slight	Moderate	Anthrax bacteria affects bison as lethal infection outbreaks. Outbreak timing and extent are unpredictable. (scope=Pervasive; Severity=Serious) Threat of predation by wolves appears to be rising. (scope=Pervasive; Severity=Slight). This threat has been observed.
8.3	Introduced genetic material	Low	Large - Restricted	Slight	Moderate - Low	Hybridization can produce less fit animals that are less likely to successfully breed and/or survive in their environments. Hybridization with cattle, domestic, or Plains Bison will likely lead to human-mediated culls at a large scale to prevent further spread of genes(Threat 5.1.3). This threat is suspected.
9	**Pollution**	**Unknown**	**Large**	**Unknown**	**High**	
9.2	Industrial & military effluents	Unknown	Large	Unknown	High	Water systems surrounding and downstream from oil exploration sites contain higher levels of pollutants than normal. Direct mortality and/or cumulative negative health effects are possible. Oil and other spills can exclude bison from a region. Bison have been observed licking or rolling in industrial effluents. This threat is suspected.
9.5	Airbourne pollutants	Unknown	Restricted	Unknown	High	Air pollution has been reported from oil and gas development, particularly in the Fort McMurray, AB, region. Road construction, land-clearing, and mining increase airbourne particulates, and the oil and gas extraction process produces airbourne chemicals. Direct impacts remain unknown, although cumulative health effects are possible. This threat is suspected.
9.6	Excess energy	Unknown	Restricted	Unknown	High	Winter drilling noise and/or lights have altered behaviour patterns. This threat has been observerd.
11	**Climate change & severe weather**	**High-Low**	**Pervasive**	**Serious-Slight**	**High-Moderate**	
11.1	Habitat shifting & alteration	Not calculated	Pervasive	Serious - Slight	Unknown	Climate change-induced habitat shifts will likely lead to drying events, more severe climate fluctuations, increased fire, and shifting forage availability. The impact of these factors is unknown. This threat is inferred.
11.2	Droughts	Low	Large	Slight	High	Wood Buffalo National Park's Peace-Athabasca Delta region has been in a drying period for decades as a result of climate change and the construction of the W.A.C. Bennett dam. As a result, vegetation is shifting, including increased spread of invasive thistle. The drought conditions reduce forage, leading to some mortality due to starvation. This threat has been observed.

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed Threats/Comments
11.3	Temperature extremes	Medium-Low	Pervasive	Moderate - Slight	Moderate - Low	Harsh winter conditions that reduce foraging ability (i.e., heavy snow/ice) have been linked to large reductions in population size. This threat has been observed.
11.4	Storms & flooding	Medium	Large	Moderate	Moderate	Flooding events have impacted >25% of Mackenzie animals in the past. Major floods can lead to up to 50% herd mortality. This threat has been observed.
12	**Other threats**		**Pervasive**	**Slight**	**Low**	
12.1	Loss of genetic diversity	Not calculated	Pervasive	Slight	Low	The entire species was reduced to ~200 animals, and all reintroduced herds have experienced further founder effects. Thus, the species is at a higher risk of inbreeding effects than normal. This threat is suspected.

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2 Description of Threats

IUCN Threat 2. Agriculture & aquaculture
2.1 Annual & perennial non-timber crops
2.3 Livestock farming & ranching

Part of the original range of Wood Bison is no longer available for recovery because of agricultural and rural development. Continuing expansion of the commercial bison ranching industry into the Wood Bison's range is further limiting the amount of land available for free-ranging bison, as is expansion of conventional agriculture with cereal crop and cattle production. These agricultural developments exclude Wood Bison from approximately 34% of their historic range because of conflicting land uses (COSEWIC 2000). The Etthithun Lake local population in British Columbia and some local populations in northern Alberta are in close proximity to agricultural lands, which limits the ability of these local populations to expand. Opposition from some commercial bison/cattle ranchers toward wild bison on the landscape is also linked to the limiting factor 'lack of public acceptance', as well as the concern of disease transfer both to and from domestic animals (Threat 8.1).

IUCN Threat 3. Energy production & mining (3.1 Oil & gas drilling, 3.2 Mining & quarrying)
IUCN Threat 5 Biological resource use (5.3 Logging & wood harvesting)
IUCN Threat 6. Human intrusions & disturbance (6.3 Work & other activities)
IUCN Threat 9. Pollution (9.2 Industrial & military effluents, 9.5 Airbourne pollutants, 9.6 Excess energy)

Open-pit mining projects such as the ones proposed for the Alberta oil sands area would displace bison from most (if not all) of the mine footprint (Threat 3.2). Concern for the long-term viability of the Ronald Lake local population that occurs on the northern periphery of oil sands development due to activities related to energy production in the oil sands area has been raised by many Indigenous groups in this region (Appendix 1). Industrial forestry, oil and gas development, mining and mineral exploration are increasing across the original range of Wood Bison, which can have negative impacts on Wood Bison and their habitat through increasing noise, human and predator access, pollution, and habitat degradation and fragmentation. However, not all resource extraction is detrimental for this species. In some instances, development may increase meadow and grassland habitat, which can be preferred habitat for Wood Bison (Mitchell and Gates 2002, Appendix 1, Mikisew Cree First Nation 2015). Opportunities may exist to maintain or "improve" available habitat through forestry and resource extraction because of the preference of bison for open areas (e.g., seismic lines). For example, habitat in the Etthithun Lake area was considered improved for Wood Bison as a result of forestry and petroleum activities (Rowe and Backmeyer 2006). In the boreal-mixed-wood forest in north-central Alberta, clear cutting (Threat 5.3) increased forage availability, but not quality, for Wood Bison; carrying capacity typically decreased when stands were greater than 8 years old (Redburn et al. 2008). In this region, clear cuts provide adequate summer forage for Wood Bison but are not suitable as winter habitat (Redburn et al. 2008).

Although forestry and resource extraction developments may initially be positive for Wood Bison by increasing available habitat, these activities also bring with them additional developments such as access roads (Threat 4.1), disturbance (Threat 6.3), pollution (Threat 9), and potentially increased predation (Threat 8.2), which can be negative to overall Wood Bison recovery. Bison

have been shown to utilize oil and gas developments during summer months when fresh forage is available, but may avoid these areas when workers are present during the winter (Appendix 1, Tan et al. 2015). Noise, lights, (Threat 9.6) and disturbance caused by winter drilling has likely altered behaviour patterns, particularly of females and younger individuals, who will avoid areas where winter drilling is ongoing (Appendix 1). Similarly, Ronald Lake local population individuals will sometimes avoid regions with noise disturbance produced during forestry activities (Mikisew Cree First Nation 2015). Developments can lead to increased human-bison conflicts, road mortality (Threat 4.1), and/or the attraction or maintenance of bison in areas where they may exhibit aggressive behaviour towards humans or damage human structures such as pipeline infrastructure or vehicles, resulting in their removal. Mortality can occur due to infrastructure itself, as animals become entrapped in the structure, though the impact of this is generally low (Threat 3.1).

A common concern raised by First Nations and Métis communities in areas near oil and gas developments was the potential for negative health impacts to bison through water and air pollution (Threats 9.2, 9.5, Appendix 1). Bison have been observed rubbing on pipelines and near oil and gas infrastructure (Beaver First Nation 2015) and in cases where spills have occurred, it is highly probable that the animals come into contact with industrial effluents. Corrosion from abandoned well sites may also lead to pollution (Appendix 1). In the Alberta oil sands region, limestone is sometimes used for road base construction, creating long lasting dust that impacts air quality (Appendix 1). Air pollution produced by regional oil sands development includes significant sulfate (Howell et al. 2014), increasing levels of nitrogen oxides in Fort McMurray and Fort McKay (Bari and Kindzierski 2015), and 'omnipresent fugitive dust' from land-clearing, mining, and hauling emissions (Lynam et al. 2015). Airbourne industrial emissions are detected at least 30 km away from their source (Lynam et al. 2015), and waterbourne pollutants are detected up to 200 km downstream (Kelly et al. 2009, 2010). Hydrogen sulfide gas release from oil and gas drilling has the potential to be a significant threat, as noted in the Hay Zama area (Appendix 1, LeNeveu 2012). The oil sands area is one of the largest producers of secondary organic aerosols in North America (Liggio et al. 2016). Oil production in the oil sands area has also been linked to the acidification of ecosystems and deposition of toxic compounds (Kelly et al. 2009, Kirk et al. 2014, Liggio et al. 2017). The long-term health effects and cumulative impacts of pollution, disturbance, and habitat modifications by industrial developments are currently unknown.

IUCN Threat 4. Transportation & service corridors

4.1 Roads & railroads

Collisions with vehicles are an important mortality factor for most Wood Bison local populations (Appendix 1, Beaver First Nation 2015, Nishi 2004, Rowe 2006). Wood Bison often use linear corridors such as road rights-of-way for grazing and spend considerable time on roads. During winters with high snow pack bison tend to use roads for travel, resulting in an increase in highway mortality (Rowe 2007). Animals will sometimes bed down on the warm asphalt in winter, and then become covered by snowfall and represent a road hazard in low visibility conditions (Appendix 1). Bison on roadways are particularly problematic at night under any weather condition (Appendix 1, Beaver First Nation 2015, Northwest Territories Environment and Natural Resources 2010). Road mortality also occurs during the rutting season when there is an increase in movement of bison along and across roads. For the Nordquist/Liard herd, the furthest dispersal along the highway occurs post-rut (Leverkus 2012). In the Hay Zama local

population in northwestern Alberta, vehicle collisions are considered the largest source of uncontrolled known mortality (Mitchell and Gates 2002). Road mortality tends to be more common between August and December in the Mackenzie local population (Northwest Territories Environment and Natural Resources 2010). Approximately 20 bison-vehicle collisions are reported each year in the Northwest Territories (Department of Transportation 2012); presumably more are unreported. The Mackenzie herd experiences the largest number of bison mortalities due to motor vehicle collisions of wild Wood Bison herds in Canada; over 380 bison were killed in vehicle collisions from 1989 to 2015 (Species at Risk Committee 2016). Highway mortality can also be associated with Northwest Territories Highway 5, which runs from Fort Smith through Wood Buffalo National Park (Appendix 1). Many preventative and educational measures have been taken in this territory and other provinces and territories for their respective herds.

Bison can also be associated with roads developed and maintained for industrial use (see industry-related Threats 3,5,6,9 above). Bison tend to follow linear features in an exploratory fashion and have done so in northeastern British Columbia, where they have come into conflict with agricultural operations, including commercial bison farms (C. Thiessen, pers. comm.). Linear developments that result in conflicting land use problems with Wood Bison are generally detrimental to recovery.

The preference of Wood Bison to follow linear disturbances may be exploited to encourage animals to move away from undesirable locations, such as highways, by clearing paths toward more suitable, safe, habitat. Prescribed burns may be a very effective way to encourage such movement (Fort Nelson First Nation and Shifting Mosaics Consulting 2015).

4.3 Shipping lanes

Some Wood Bison local populations make extensive use of rivers in their ranges. As a result, summer and winter river crossings can be common. While Wood Bison tend to be good swimmers, increased water vehicular traffic for recreation, transportation, or seismic exploration could result in bison mortality through direct vehicle collisions or the creation of waves or choppy water that can swamp bison swimming across rivers (Larter et al. 2003). This is especially a threat for the Nahanni local population that often crosses the Liard River (Larter et al. 2003). Bulls and calves are likely most susceptible, as they swim with their noses only a few inches above the water.

IUCN Threat 5. Biological resource use

5.1 Hunting & collecting terrestrial animals

5.1.1. Intentional Use

Bison are hunted for Indigenous traditional use and are of cultural importance to many Indigenous peoples. The Ronald Lake local population has high importance for the First Nations and Métis peoples in the area, since it is the only local population in the region that is disease-free and can be legally hunted (Appendix 1). The Indigenous and historic harvest of this population is locally considered to be sustainable, but with access into the area increasing with rising industrial activity, the herd was thought to be facing considerably higher sport and trophy hunting pressure, potentially representing a significant threat (Appendix 1). On March 31, 2016, the province of Alberta listed this herd under the provincial Wildlife Act as a Subject Animal, restricting the

non-Indigenous hunt. Prior to this, the hunt on this herd was provincially unregulated. In other parts of the range, where hunting is regulated, hunting may not be a threat to Wood Bison recovery. Hunting tags for the Aishihik and Hay Zama herds are issued yearly to control population numbers and limit the geographic spread of the herds (Threat 5.1.3). Increased access to hunting bison has been shown to increase public acceptance, as the perceived value of these animals on the landscape is increased. Thus, while unregulated hunting is a significant threat, as is the control of Wood Bison movement across the landscape (Threat 5.1.3), permitting hunting of populations where it can be done sustainably may help to improve public acceptance and have a positive impact on Wood Bison recovery overall.

5.1.3 Control/Persecution

In addition to the negative impact that bovine tuberculosis and brucellosis have on the productivity of infected populations (Threat 8.1), the presence of diseased bison on the landscape constrains the ability to allow for the future expansion and re-establishment of disease-free bison local populations in large areas of their original range (FEARP 1990, COSEWIC 2000). To prevent disease transmission to the Mackenzie local population from animals in the Wood Buffalo National Park metapopulation, the Government of the Northwest Territories has created a Bison Control Area, a 39,623 km^2 bison-free buffer zone between the Mackenzie and Wood Buffalo National Park local populations (Figure 3). Within this area, aerial surveillance is conducted annually, bison are removed and disease-tested, and hunting (Threat 5.1.1) is unregulated (Gates et al. 2001b, Nishi 2002). Similarly, the Government of Alberta established a 36,000 km^2 Bison Protection Area surrounding the Hay Zama local population (Figure 3), within which bison hunting is regulated to limit population growth to minimize the risk of disease transmission from the Wood Buffalo National Park metapopulation, and to assess its disease status (Government of Alberta 2015). Hunting of Wood Bison is otherwise unregulated in Alberta, except in national parks and the area surrounding the Ronald Lake local population where bison are considered a Subject Animal under Alberta's *Wildlife Act* and non-Indigenous hunting is not allowed, to create a buffer zone between diseased Wood Buffalo National Park area bison and the disease-free Hay Zama local population (Gates et al. 2001b). This includes the area to the east of Wood Buffalo National Park. However, less lethal alternatives to discourage Wood Bison from entering these buffer zones could be evaluated, such as encouraging animals to use more 'desired' locations through creation of linear features, prescribed fire and connectivity between herds, or cattleguards (Appendix 1).

The hybridization of free-ranging Wood Bison with free-ranging Plains Bison, domestic bison, and cattle is also a threat (Threat 8.3) and management/control actions have been enacted to mitigate this threat. In British Columbia, a free-ranging Plains Bison population (Pink Mountain) was established within the original range of Wood Bison in 1971, precluding recovery of Wood Bison at this site. In 2003, this population was estimated to have a size of 876 animals (COSEWIC 2004). As a result, a Wood Bison Protection Area was designated as an active control zone (Figure 3) to prevent the hybridization of the Nordquist/Liard, Nahanni, and Hay Zama Wood Bison local populations with the Pink Mountain Plains Bison (Harper et al. 2000).

While presently important in mitigating the threats posed by hybridization and disease, management zones inhibit natural dispersal and gene flow between Wood Bison local populations and the potential re-establishment of Wood Bison populations in these areas

(COSEWIC 2000), further limiting Wood Bison recovery through the loss of genetic diversity in isolated populations.

IUCN Threat 7. Natural system modifications

7.1 Fire & fire suppression

Fire naturally acts to maintain meadow habitat preferred by Wood Bison. Wood Bison habitat may be lost or degraded through fire suppression, which can result in the transition of meadow habitats to shrubs and trees in the absence of other perturbations such as flooding (Quinlan et al. 2003). As such, fire suppression is considered a threat to Wood Bison recovery. Prescribed burning, however, can be an effective management tool to improve foraging habitat for Wood Bison (Fort Nelson First Nation and Shifting Mosaics Consulting 2015). In the Northwest Territories, up to 270 km^2 were managed with fire in some years (Chowns 1998) and smaller areas near Nordquist Flats in British Columbia have benefited from fire to improve habitat for Wood Bison. Modifying policies to reduce fire suppression in large expanses of unoccupied crown land could serve to enhance or create meadow habitat for Wood Bison. Fort Nelson First Nation in British Columbia has a long tradition of using fire to regenerate the landscape in their territory and has documented the benefits for Wood Bison (Fort Nelson First Nation and Shifting Mosaics Consulting 2015). As such, fire management that emulates natural fire regimes is not considered a threat to bison. However, fires can lead to direct mortality and bison do avoid recently burned areas, returning once the regrowth of the area has begun (Appendix 1). If fires are particularly hot or large, this can exclude bison from a large region for a longer period of time, reducing forage capacity and suitable habitat and increasing the potential for starvation (Appendix 1). Unusually hot fires can result from a buildup of fuel in the system due to prolonged fire suppression. Climate change and drought (Threat 11) may lead to shifting fire regimes.

7.2 Dams & water management/use

The construction of dams on rivers such as the Peace River has induced changes in the hydrological regime of areas such as the Peace-Athabasca Delta (see for e.g. Peters and Prowse (2001)). These hydrological changes have, in turn, modified meadow succession (Carbyn et al. 1993, Gates et al. 2001b). Natural variation and climate change in addition to dam construction may have contributed to these changes, but the relative contribution of each is unknown. Similar to the Peace-Athabasca Delta, the meadows downstream on the Slave River Basin do not receive the same amount of flooding they once did, although natural variation and climate change in addition to dam construction may have contributed to this change (Timoney 2006). Reduced flooding of these areas has affected the vegetation community, causing a shift from sedges (important winter forage for bison) to grass, forbs, and shrubs, thereby reducing habitat availability (Prowse and Conly 2002, Townsend 1975). Increased spread of invasive thistle (Threat 8.2) may also be associated with the lack of seasonal flooding resulting from the construction of the W.A.C. Bennett Dam or other hydrological changes (Appendix 1, Candler et al. 2015, Mikisew Cree First Nation 2015, Timoney 2013). Local residents of the Peace-Athabasca Delta region noted that bison movement patterns were historically predictable, where animals would move to higher ground at the time of spring flooding (Appendix 1). Without the annual flood, movement patterns are no longer reliable.

IUCN Threat 8. Invasive & other problematic species & genes
8.1 Invasive non-native/alien species

Two introduced, cattle-derived diseases, bovine tuberculosis and bovine brucellosis, occur in some wild bison populations in the Wood Buffalo National Park area. Both diseases were introduced into bison from infected cattle and can be transmitted among wildlife (including species at risk), livestock, and to humans, especially hunters (Nishi et al. 2006). Joly and Messier (2004b) found exposure rates for bovine tuberculosis and brucellosis of 49% and 31%, respectively, in Wood Buffalo National Park.

Bovine tuberculosis and brucellosis can potentially limit populations because they are chronic diseases that negatively affect fecundity and survival (Fuller 1962, Joly and Messier 2004a, Joly and Messier 2005). Advanced tuberculosis causes an estimated annual mortality of 4-6% of bison in Wood Buffalo National Park (Fuller 1962, Tessaro 1987). Bison that tested positive for both bovine tuberculosis and brucellosis in Wood Buffalo National Park had reduced winter survival and reproductive rates (Joly and Messier 2005), influenced in part by the interactions among disease presence, habitat quality, and wolf predation. However, the relationships between these variables in Wood Buffalo National Park are complex and poorly understood, with conflicting interpretations of how the system functions (Carbyn et al. 1993, Joly and Messier 2004a, Bradley and Wilshurst 2005).

There is currently no vaccine that has demonstrated efficacy for tuberculosis in bison. There is an effective vaccine for the control of brucellosis in bison but vaccinating wild populations is challenging (Shury et al. 2014).

Because management actions have to be undertaken to decrease the risk of disease transmission from diseased Wood Bison, efforts to reach the short-term population and distribution objectives may impede or delay achievement of the long-term population and distribution objectives. The potential transmission of bovine tuberculosis and brucellosis to disease-free Wood Bison carries ecological and human health implications for sustainable harvesting by local communities (Gates et al. 2001b, Nishi et al. 2006). Contraction of bovine brucellosis and/or tuberculosis by disease-free populations can lead to drastic management actions. In 2006, the entire captive Hook Lake Wood Bison Recovery Project local population was destroyed after bovine tuberculosis was detected in the conservation project (Lutze-Wallace et al. 2006). As such, these diseases are indirectly limiting populations because management interventions have to be taken to control diseases by reducing population growth, size, and distribution (Threat 5.1.3).

Control measures can be sporadic and have no guarantee of success, and thus are not an effective long-term solution to controlling the spread of these diseases. Furthermore, there are no control areas separating diseased local populations from the disease-free Ronald Lake and Wabasca local populations, which are both in close geographic proximity to diseased local populations. It also remains important to recognize the potential for future transmission of these and other zoonotic diseases between domestic and wild animals, in both directions. Encroachment by domestic species, such as bison, cattle, sheep, and goats, into the current wild bison range represents a potential risk to be monitored.

Additionally, *Mycobacterium avium* subspecies *paratuberculosis* (MAP), the causative agent of Johne's disease, has been detected in all free-ranging and captive Wood Bison local populations

tested (Forde et al. 2013). It is not known what, if any, impacts these bacteria have on Wood Bison at an individual or population level, as only one clinical case has been identified to date in Wood Bison (Forde et al. 2013). The presence of MAP may have significance for Wood Bison translocation given the potential for regulatory and import disease-testing requirements, and it is recommended that animals be translocated between herds of similar health status.

Canada Thistle (*Cirsium arvense*) is an aggressive invasive weed that has been increasingly spreading in the Wood Buffalo National Park region for the last several decades. Although the cause of its introduction is unknown, it appears to be spreading from the center of the park outward, leading to speculation that it was brought in with hay for livestock in the mid-1900s. Increased drying (Threats 7.2, 11.1, 11.2) and fire (Threat 7.1) appear to promote the survival and spread of this species (Appendix 1). Seasonal flooding was thought to reduce weed abundance, and invasive thistle is frequently observed in dried out regions. Flooding events are less frequent in the Peace-Athabasca Delta since the construction of the W.A.C. Bennett Dam (Threat 7.2, Appendix 1, Candler et al. 2015, Mikisew Cree First Nation 2015, Timoney 2013), which may be aiding the spread of invasive thistle. It is also a rapid recolonizer after a fire (Appendix 1), outcompeting native plants. Bison in Wood Buffalo National Park avoid regions where thistle is prominent as they will not walk through the area and do not eat thistle (Candler et al. 2015, Appendix 1). This may be a mechanism that maintains the separation between the diseased Wood Buffalo National Park and disease-free Ronald Lake local populations, but Ronald Lake bison may be forced to move in to this suboptimal habitat if development continues in their herd range (Candler et al. 2015, Appendix 1). Plains Bison in Prince Albert National Park avoid Canada Thistle in summer but select it in winter despite being a suboptimal food source, likely because it is easier to locate as it tends to stand up out of the snow (Fortin et al. 2003). With increased drying conditions predicted with climate change (Threat 11), this noxious weed will likely continue to expand, further decreasing available forage and suitable habitat for bison.

Non-native seed mixes are sometimes used in reclamation projects. This can impact bison movements, as they may be drawn to these areas if they prefer the non-native plants, or avoid them if they prefer native species. Rules and recommendations regarding seed mixes for reclamation projects vary widely with industry and jurisdiction. Using appropriate native seed mixes in the Northwest Territories is especially difficult, due to a lack of knowledge on seed production and successional processes, and a lack of available seeds indigenous to the Northwest Territories (Mackenzie Valley Land and Water Board 2013, Aboriginal Affairs and Northern Development Canada 2015). Non-native plant seeds can also be dispersed along roadways via vehicular travel (Ansong and Pickering 2013), which again may impact bison use depending upon whether they prefer or avoid the non-native plants (D. Allaire, pers. comm.).

As there is the potential for diet competition between Wood Bison and feral horses, it is possible that feral horses could pose a threat to Wood Bison in situations where forage is limited (Jung et al. 2015b).

8.2 Problematic native species

Extreme anthrax outbreaks

Anthrax (*Bacillus anthracis*) bacterial infections are a concern for Wood Bison populations, because anthrax spores are highly resistant and long-lived, persisting in soils of meadows

preferred by Wood Bison. Bison do not carry the bacteria, and are only affected during outbreaks (Bison Disease Task Force (BDTF) 1988). During outbreaks, infected animals suddenly become ill and die, although the disease can also be nonlethal (Bagamian et al. 2013). It is not possible to estimate an infection rate for anthrax due to the disease ecology. Anthrax spores disperse into the local environment by the release of body fluids from infected and dead animals through body orifices or via scavenging, which then become a potential source for disease outbreaks in the future (BDTF 1988). Certain environmental and climatic conditions appear to be required to expose animals to concentrations of spores, which is followed by explosive outbreaks of the disease (Dragon and Rennie 1995, Gates et al. 1995, Hugh-Jones and Blackburn 2009). Timely and effective carcass cleanup reduces localized environmental contamination of anthrax spores (Nishi et al. 2003, Elkin et al. 2013, McNab 2015).

Anthrax outbreaks have occurred within the range of Wood Bison in the Slave River Lowlands, Wood Buffalo National Park, and Mackenzie Wood Bison local populations (Gates et al. 1995, Nishi et al. 2002b, Nishi et al. 2007). The majority of previous anthrax outbreaks did not appear to significantly affect bison population dynamics (BDTF 1988, FEARP 1990). However, outbreaks can sometimes be quite extreme, affecting animals in all age classes and reducing population numbers up to 50%. For example, between 1962 and 1964, 948 bison deaths in the Slave River Lowlands and Wood Buffalo National Park were attributed to anthrax (Elkin et al. 2013, McNab 2015, Species at Risk Committee 2016). From 1962 to 2015, there have been at least 23 documented outbreaks killing at least 2266 bison in the three areas (Species at Risk Committee 2016). In 2012, a record outbreak in the Mackenzie herd resulted in a mortality rate of approximately 50% (~451 deaths), including cows and young bison (McNab 2015, Species at Risk Committee 2016). Continued outbreaks of this magnitude could impact population dynamics, social structure, and genetic diversity in the area. Currently, there are effective vaccines for the control of anthrax, but vaccine delivery is challenging in free-ranging populations.

Increased predation

The wolf-bison predator-prey relationship has co-evolved over many years and their unbroken relationship in Wood Buffalo National Park is one of the Outstanding Universal Values (OUV) of the park as a UNESCO World Heritage Site (http://whc.unesco.org/en/list/256). Wolf and bear predation are naturally occurring factors for Wood Bison survival where they co-occur (Van Camp 1987, Carbyn et al. 1993, Varley and Gunther 2002), but may regulate diseased herds occurring at low densities via the "diseases-predation hypothesis". This hypothesis, proposed by Messier (1989) and Gates (1993), suggests that bovine tuberculosis and brucellosis reduce productivity and increase the vulnerability of infected individuals to predation, with the interaction resulting in a decline in bison abundance. Simulation studies by Joly and Messier (2004a) suggested that Wood Bison populations that are infected with tuberculosis and brucellosis are more likely to exist at low densities if they are also experiencing wolf predation. However, Bradley and Wilmshurst (2005) postulated that the population decline of Wood Bison in Wood Buffalo National Park during the 1970s and 1980s could be explained by low juvenile survival due to predation, without invoking the effects of diseases. Thus, while alternate hypotheses exist, increased predation and its interplay with disease should be considered a threat to bison recovery. Grizzly and black bears (*Ursus americanus*) occur in large parts of the Wood Bison range, and their impact on population dynamics through calf predation is unknown.

Communities across the present range of Wood Bison report dramatically increasing numbers of wolves and in many cases, noticeable increases in wolf predation on bison (Appendix 1, Mikisew Cree First Nation 2015). In deforested regions (Threat 5.3), the decreased tree cover is suspected of raising bison susceptibility to predation (Mikisew Cree First Nation 2015). Wolves may also be using linear features, such as those resulting from oil and gas activity, as hunting corridors and to gain access to areas where they didn't travel previously. This is also thought to be increasing the predation threat to Wood Bison (Appendix 1). The mortality rate attributed to increased wolf presence is currently unknown, but was highlighted across the range of the species. For recently introduced herds, wolf predation appears to be increasing, presumably as wolf packs adapt to bison on the landscape and learn to hunt them (Larter et al. 1994, Jung 2011).

8.3 Introduced genetic material

The hybridization of free-ranging Wood Bison with free-ranging Plains Bison, domestic bison, and cattle is a potential threat because it can compromise Wood Bison genetic integrity and introduce detrimental traits. In 2006, there were approximately 196,000 Plains Bison on about 1,900 Canadian farms (Canadian Bison Association 2009). The majority of animals used in commercial bison ranching in Canada are Plains Bison or bison of unknown genetic makeup. The proliferation of bison ranches and their encroachment into the original range of Wood Bison (Threat 2.3) increases the risk of escape or release of domestic animals, which could threaten the genetic integrity of free-ranging Wood Bison local populations.

There has been widespread cattle gene introgression in Plains Bison populations across North America (Polziehn et al. 1995, Ward et al. 1999). Cattle introgression has been shown to reduce male height and weight in some populations of Plains Bison (Derr et al. 2012), which could have a negative impact on fitness. No evidence of cattle introgression has been described in Wood Bison to date; however, statistical confidence is low due to small sample sizes (Halbert and Derr 2007). The encroachment of cattle ranching into original Wood Bison range increases the risk that hybridization between these species will occur.

IUCN Threat 11. Climate change & severe weather
11.1 Habitat shifting & alteration, 11.2 Droughts, 11.3 Temperature extremes, 11.4 Storms & flooding

Climate change is anticipated to have a negative net impact on Wood Bison habitat, including a reduction or removal of ecological barriers that limit range occupancy by bison, changes in pathogen host distribution, transmission and effects of pathogens, and habitat composition (Threat 11.1). Wood Bison are distributed within three climatic regions where the highest rates of warming in Canada (60 year warming trend of 2.2°C to 2.4°C in annual temperature, Threat 11.3) are predicted (Environment Canada 2007). Climate change has influenced, and will continue to influence, the extent of water and flooding (Threat 11.2) of the Peace-Athabasca Delta in Wood Buffalo National Park (along with the construction of the W.A.C. Bennett dam), and has the potential to be a significant threat to Wood Bison recovery. Climate change and drought (Threat 11.2) may shift the fire regime, leading to habitat alteration, the detriments or benefits of which to bison are unknown and depend on fire severity (Threat 11.1). The reduction in flooding in the Hay Zama area has reduced the availability of open grassy meadows that bison use (Beaver First Nation 2015). Extreme flooding (Threat 11.4) can have significant population impacts via mass drowning, as occurred in 1974 in the Peace-Athabasca Delta in Wood Buffalo National

Park when 3,000 bison died in a severe flood (Appendix 1, Environment Canada 1989). Extensive flooding has also reduced availability of meadow habitats and shifted the distribution of the Mackenzie local population (Northwest Territories Environment and Natural Resources 2010). Bison can also drown by falling through thin ice in the spring, which has impacted the Mackenzie and Nahanni local populations (D. Allaire, pers. comm.). Freeze-thawing events may become more common with climate change. Though some drowning events are a naturally limiting factor, unusually large flooding events pose a threat due to the severity of their impact on the population. Harsh winters with heavy snowfall or thick ice formation via freezing rain or snow melts (Threats 11.3, 11.4) can lead to bison starvation (Beaver First Nation 2015). High mortality (~20%) was observed in the Hay Zama local population in 2012, which was attributed to starvation due to harsh winter conditions (COSEWIC 2013).

It should also be noted that some impacts of climate change might increase habitat quantity and quality for Wood Bison. For example, the amount of grassland is expected to increase in northern Alberta, northern British Columbia, and Yukon, which may result in increased habitat for bison in these areas (Rehfeldt et al. 2012).

IUCN Threat 12. Other Threats
12.1 Loss of genetic diversity

All disease-free Wood Bison local populations besides Ronald Lake and Wabasca have either been established from relatively few founders (Elk Island National Park, Mackenzie), or have been founded from Elk Island National Park (Appendix 3), and therefore, have lower genetic diversity than the original source population in Wood Buffalo National Park (Wilson and Strobeck 1999, Wilson et al. 2005). Furthermore, several local populations are maintained at an artificially small size to prevent range expansion and contact between diseased and disease-free local populations, to manage the risk to people and property in communities, and to provide hunting opportunities (Threat 5.1). In general, smaller populations have lower genetic diversity and are subject to higher genetic drift over time. Genetic diversity within populations can be increased by allowing migration between populations; however, few movement corridors are available among Wood Bison local populations, and there is active control of movement between most diseased and disease-free local populations. Low levels of genetic diversity can have serious implications for population survival through inbreeding depression, which may reduce population fitness and increase the probability of population extirpation. Inbreeding depression has been linked to low levels of calf recruitment and high levels of calf mortality in a Plains Bison population (Halbert et al. 2004, 2005), while low levels of genetic diversity have been associated with higher disease prevalence in European Bison (*Bison bonasus*; Luenser et al. 2005). In the long-term, low levels of genetic diversity can reduce the ability of a population to adapt to changing environmental conditions, such as those resulting from climate change, and its ability to respond to natural selection pressures (summarized in McFarlane et al. 2006). Consequently, the small founding size of most Wood Bison local populations, combined with the current small size of some local populations and the lack of animal movement among local populations, raises concerns about levels of genetic diversity in Wood Bison local populations.

5 Population and Distribution Objectives

Population and distribution objectives for the Wood Bison are set at two time-scales: short-term and long-term. This two-staged approach is necessary because of the complexity of the disease issue and the ongoing uncertainty as to how to eliminate the threat of exotic bovine diseases in the species over the long-term. Due to this complexity, population and distribution objectives are not proposed for existing diseased Wood Bison local populations at this time. Instead, the competent Minister will propose population and distribution objectives for diseased local populations, informed by the work of a collaborative process to be established to explore management options for these local populations and their impact on Wood Bison recovery.

The short-term population and distribution objective is to maintain the disease-free status, population size and range of all disease-free Wood Bison local populations within the original range of Wood Bison in Canada. If future work shows that some of these local populations are not self-sustaining, population size and/or range size should be increased so that self-sustaining status can be attained. For local populations that currently exceed 1,000 animals, population reductions may sometimes be necessary to improve public acceptance (Clark et al. 2016), so long as the minimum population size of 1,000 animals as set by the long-term population objective remains met.

If there are local populations for which the disease status is currently uncertain, the local populations and the ranges in which they occur should be maintained until such time as their disease status is ascertained. Local populations that are shown to be disease-free, or from which bovine tuberculosis and brucellosis have been eliminated, would be included under the population and distribution objective above.

Extralimital[9] and captive local populations managed for conservation should also be maintained. Both of these can act as important reservoirs to protect Wood Bison and their genetic diversity from catastrophes that may occur within current populations, helping to secure the subspecies in local ecosystems. The Chitek Lake local population is also of cultural significance to the Manitoba Metis community (Manitoba Metis Federation Inc. letter to ECCC, June 27, 2016).

The maintenance of genetic diversity in diseased and disease-free local populations is also a critical component of Wood Bison recovery. This is especially true for the Wood Buffalo National Park and surrounding local populations, which retain the greatest level of genetic diversity (Wilson et al. 2001) as they are naturally established populations, compared to those established by human-mediated translocation. . Additionally, these bison are valuable for socio-cultural connections to Indigenous groups as well as their fundamentally important ecological role in the surrounding ecosystem.

The long-term population and distribution objective is to ensure the existence of at least five disease-free, genetically diverse, connected, self-sustaining, free-ranging local populations distributed throughout their original Canadian range, with a minimum size for each local

[9] Extralimital refers to those herds outside the original range of Wood Bison in Canada as shown in Figure 2.

population of 1,000 animals. The long-term population and distribution objective is meant to build on the short-term population and distribution objective, not replace it.

The target population size of 1,000 animals was chosen based on modeling studies performed to estimate the loss of genetic diversity in Wood Bison populations over time. Gross and Wang (2005) found that 1,000 bison are required to achieve a 90% probability of retaining 90% of allelic diversity. The number of local populations is based on professional judgement and expertise of members within the now-dissolved Wood Bison Recovery Team as to how many local populations might ensure species recovery throughout the original range in Canada. In order to meet this objective, some existing local populations may merge to form a larger population. Local populations of 1,000 animals that meet the long-term population and distribution objectives may also end up occurring in locations where there are currently no Wood Bison. Smaller local populations maintained in a natural state throughout and external to the original range of Wood Bison play an important role in Wood Bison recovery, helping to secure the subspecies in local ecosystems.

The population and distribution objectives are not achieved until local population levels are sufficient to sustain harvesting activities, consistent with existing Aboriginal and Treaty rights of Aboriginal peoples of Canada. Indigenous harvest may be supported for local populations of any size, so long as the Wood Bison local population remains self-sustaining. Maintaining a self-sustaining population is traditionally part of Indigenous herd management (Appendix 1).

6 Broad Strategies and General Approaches to Meet Objectives

6.1 Actions Already Completed or Currently Underway

Since the first national Wood Bison Recovery Plan was published (Gates et al. 2001b), a number of scientific studies relating to recovery of Wood Bison in Canada have been completed or are ongoing. A partial list of pertinent publications can be found below.

Research

- Numerous reports on disease management and genetic salvage have been published (e.g., Nishi et al. 2002a, b, Joly and Messier 2004 a, b, Bradley and Wilmshurst 2005, Joly and Messier 2005, McFarlane et al. 2006, Nishi et al. 2006, Woodbury et al. 2006, Nishi et al. 2007, Thundathil et al. 2007).
- A Bison Disease Technical Workshop was held in 2005 to examine the technical feasibility of eliminating bovine diseases from the Wood Buffalo National Park ecosystem (Shury et al. 2006).
- Several studies on the genetic diversity of Wood Bison and techniques for maintaining this diversity have been carried out and published (e.g., Wilson et al. 2003, Wilson and Zittlau 2004, Wilson et al. 2005, McFarlane et al. 2006, Ball et al. 2016).
- Studies assessing the role of predation in Wood Bison at Wood Buffalo National Park and their historical declines have been completed (Joly and Messier 2004a, Bradley and Wilmshurst 2005).

- Studies assessing competition between Wood Bison and other species have been performed (Fischer and Gates 2005, Kuzyk and Hudson 2007, Jung et al. 2015a, Jung et al. 2015b).
- Studies have been completed on vaccines for *Brucella abortus* in both bison and cattle (Clapp et al. 2011, Treanor et al. 2010, Denisov et al. 2010, Hu et al. 2009, 2010), and studies are being planned to look at effectiveness of vaccine for tuberculosis in bison.
- Parks Canada and Government of the Northwest Territories have initiated a joint review of their Bison Control Area program to review its efficacy and success to date in meeting its objectives, and determine where improvements can be made.
- The presence of *Mycobacterium avium* subspecies *paratuberculosis* (MAP) has been detected and characterized in all nine Canadian herds tested (Forde et al. 2013).
- Research has shown that Wood Bison in the Etthithun Lake and Nordquist local populations preferably select linear features and other anthropogenic structures, and this may have a negative impact on survivorship (Leverkus 2015).
- Research on the socio-economic impacts of bison reintroduction to First Nation and local people has been completed in Yukon (Beach and Clark 2015, Clark et al. 2016).
- A technical team has been established with membership from Environment and Climate Change Canada, the Province of Alberta and Indigenous and industrial partners to identify and obtain the knowledge necessary to inform management of the Ronald Lake bison herd.

Management

- Reports describing the implementation of bison control areas have been published (e.g., Government of Alberta 2015, Northwest Territories Environment and Natural Resources 2012).
- Several reintroduced free-ranging local populations (Aishihik, Hay Zama, Mackenzie) currently have highly managed hunts, where quotas are determined by the province/territory for both the Indigenous and non-Indigenous hunts. Quotas are based on herd population dynamics and socioeconomic factors to manage herd expansion and increase public acceptance.
- Management plans for several local populations have been completed or are in development (e.g., Cool 2006, Rowe 2006, Northwest Territories Environment and Natural Resources 2010, Harper et al. 2000, Government of Yukon 2012b).
- Recommendations for use of fire in the management of Wood Bison have been proposed (Fort Nelson First Nation and Shifting Mosaics Consulting 2015).
- Programs are in place in Fort Providence and Fort Liard (NT) to move bison out of communities (Northwest Territories Environment and Natural Resources 2010).
- Public messaging and campaigns are in place in NT to reduce bison-related traffic accidents (Northwest Territories Environment and Natural Resources 2010) and bright, reflective collars have been tested on bison in BC to increase visibility on roadways (Leverkus 2012).
- Wood Bison in the general vicinity of the Ronald Lake local population were identified as Subject animals under Alberta's Wildlife Act in 2016, which results in the control of non-Indigenous hunting in the area.

Habitat

- Several studies on forage availability and habitat use by Wood Bison have been published (e.g., Quinlan et al. 2003, Redburn et al. 2008, Strong and Gates 2009, Jung 2015).
- Work to identify seasonal range patterns has been carried out using radiocollar telemetry data for the disease-free Ronald Lake (Tan et al. 2015) and Ettithun (Leverkus 2012) local populations.
- Seasonal behavioural and general habitat use patterns for some herds have been documented, incorporating local community and indigenous knowledge (e.g. Leverkus 2012, Candler et al. 2015, Schram *unpublished*).

6.2 Strategic Direction for Recovery

Table 5. Recovery Planning Table for Wood Bison

Threat or Limitation	Priority[a]	General Description of Research and Management Approaches
Broad strategy: Contain and prevent the spread of bovine tuberculosis and brucellosis from Wood Bison local populations with diseases to disease-free local populations, cattle, and ranched bison, and evaluate current disease management options.		
Invasive non-native species (Threat 8.1); Persecution/Control (Threat 5.1.3)	High	Examine the feasibility of various alternatives for elimination of the threat of bovine diseases from wild bison in local recovery populations, over the long-term, while conserving genetic diversity. While depopulation and repopulation is one approach, there is also long-term potential for the development of improved tests to detect tuberculosis and brucellosis, effective vaccines, and other disease management tools
		Develop a contingency plan for disease and genetic management in the event a disease-free local population becomes infected with bovine tuberculosis and/or brucellosis
		Conduct periodic disease testing of all local populations to confirm status and assess changes in prevalence over time
		Establish a collaborative multi-stakeholder bison disease management planning group to examine options and coordinate activities aimed at eliminating the risk of bovine brucellosis and tuberculosis transmission
		Develop a contingency plan for disease and genetic management in the event of a conflict with the livestock industry
		Evaluate the effectiveness of bison control areas in reducing the risk of the spread of bovine brucellosis and tuberculosis to non-diseased local populations, until such time as the risk of bovine brucellosis and tuberculosis transmission is eliminated, as required to meet the long-term population and distribution objectives
		Assess the risk of infection with bovine tuberculosis and brucellosis to people who handle or eat infected bison and develop guidelines to reduce risk of transmission
		Improve communication to local hunters about the safety level of meat, where lacking.

Threat or Limitation	Priority[a]	General Description of Research and Management Approaches
Broad strategy: Maintain at least 90% of the genetic diversity, as measured by allelic diversity, within the Wood Bison subspecies and local recovery populations for the next 200 years.		
Loss of genetic diversity (Threat 12.1)	High	Determine specific methods to obtain reproductive material from genetically diverse local populations with diseases
		Evaluate methods for enhancing genetic diversity of disease-free local populations
		Identify areas of suitable habitat for Wood Bison throughout their range where reintroduction might be possible to ensure that genetically diverse, disease-free, connected local populations occur throughout their original Canadian range
		Jurisdictional collaboration for the successful reintroduction of Wood Bison to parts of their range where they are absent to ensure that disease-free, genetically diverse, connected Wood Bison local populations occur throughout their original Canadian range
Broad strategy: Increase potential for connectivity among isolated local free-ranging, disease-free populations, and for population expansion (after the risk of brucellosis and tuberculosis transmission has been eliminated).		
All threats	High	Develop and implement plans to facilitate population growth and/or range expansion for local populations that do not currently meet the long-term objective of connected populations of at least 1,000 animals, where appropriate
All threats	Medium	Assess habitat within and surrounding Wood Bison local populations that seem to have stabilized at a small size. If habitat does not appear to be limiting the size of these local populations, assess other potential limiting factors
Fire & fire suppression (Threat 7.1)	Medium	Determine the potential for using prescribed burning to create, improve, and maintain bison habitat across the range
Agriculture (Threat 2); Energy production & mining (Threat 3); Logging & wood harvesting (Threat 5.3); Human intrusions & disturbance (Threat 6)	Medium	Evaluate methods for integration of bison habitat management with forestry, oil and gas development, mining, exploration for natural resources, and reclamation of industrial sites

Threat or Limitation	Priority[a]	General Description of Research and Management Approaches
Broad strategy: Address and reduce additional important key threats to Wood Bison and their habitat.		
All Threats	High	Determine and implement best management practices to achieve conservation of suitable habitat, and reduction or elimination of threats
All Threats	High	Monitor changes in population size for each local population through time, and attempt to determine reasons for declines in population size where they are observed (i.e., disease, predation, etc.).
Transportation and service corridors (Threat 4)	High	Identify, evaluate, and implement measures to reduce collisions with vehicles on land and water
Introduced genetic material (Threat 8.3)	Low	Manage genetic integrity by preventing free-ranging Plains Bison, domestic bison, and cattle from hybridizing with Wood Bison through controlling, eliminating and/or preventing incursion of these animals into areas with Wood Bison
		Develop guidelines and regulations for bison producers in areas near free-ranging herds of Wood Bison to ensure the risk of mixing and hybridization of domestic bison with Wood Bison is minimized
		Identify and evaluate the extent of potential conflicts between the domestic bison and cattle industries and habitat availability for free-ranging Wood Bison
Dams & water management/use (Threat 7.2); Climate change & severe weather (Threat 11)	Medium	Evaluate changes to hydrology and implications for bison habitat, particularly in the Lower Peace River, the Peace-Athabasca Delta, and the Slave River Lowlands, and determine management actions to ensure that habitat quality does not continue to decline from hydrological changes
Invasive & native problematic species (Threat 8)	Low	Better understand of the interactions among Wood Bison, other herbivore species, vegetation (including invasive thistle), and predator populations
Broad strategy: Increase public awareness and acceptance for Wood Bison, including acknowledging and augmenting social, cultural, ecological, and economic relationships among Wood Bison and Indigenous peoples and local communities.		
Lack of public acceptance (Limiting Factor)	Medium	Where population size allows it, support regulated Indigenous and non-Indigenous hunting to increase acceptance of bison on the landscape (Appendix 1)
		Increase public awareness and involvement in Wood Bison recovery and habitat management to maintain or improve the public's acceptance of Wood Bison

Threat or Limitation	Priority[a]	General Description of Research and Management Approaches
		Educate land users (ranchers, farmers, hunters, etc.) to reduce negative interactions with Wood Bison and habitat loss caused by their activities
		Identify and address bison-human conflicts, particularly near residences and communities
		Collaborate with Indigenous groups, land owners, land managers, government agencies and other relevant parties to promote, coordinate and implement habitat management and conservation efforts

[a] *"Priority" reflects the degree to which the broad strategy contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species.*

6.3 Narrative to Support the Recovery Planning Table

Contain and prevent the spread of bovine tuberculosis and brucellosis from Wood Bison local populations with diseases to disease-free local populations cattle, and ranched bison, and evaluate current disease management options.

The existence of bovine tuberculosis and brucellosis in Wood Bison indirectly limits local population growth of the species and will always pose a threat to surrounding disease-free local populations, domestic bison, cattle, and people, unless the threat of disease transmission is eliminated from infected local populations. The perceived risk of diseased bison on the landscape by provincial and territorial governments, communities, and stakeholders has a great impact on Wood Bison management and recovery. Without the risk of disease spread, there would be no need for bison control areas in Alberta and Northwest Territories, increasing available range and gene flow in this area. There is currently a vaccine available for the control of brucellosis in bison (RB51), but no vaccine has demonstrated efficacy for tuberculosis in bison. Also, it should be noted that brucellosis is unlikely to be eradicated through an RB51 vaccination program alone (Olsen et al. 2003), and research on the development and efficacy of tuberculosis vaccines for cattle and badgers in Great Britain has proven to be challenging, time-consuming, and resource-intensive (see Chambers et al. 2014).

Containment strategies cannot guarantee 100% effectiveness in perpetuity, although they are extremely important in the short-term to mitigate the risk of spread of bovine tuberculosis and brucellosis. Preventing the spread of these diseases from diseased local populations in the Wood Buffalo National Park metapopulation will require the development and implementation of interim management measures that, at a minimum, will contain the spread of these diseases. Presently, control activities to decrease the risk of disease transmission to healthy local populations consist primarily of aerial surveillance within defined management areas, followed by the removal of bison within control/buffer zones (Nishi 2002). Other interim actions, such as population reduction and disease testing, are underway in Alberta (Government of Alberta 2015). In addition, a contingency plan must be developed to address the scenario of potential disease transmission to currently uninfected Wood Bison recovery local populations. The National Wildlife Disease Strategy (2004) provides an opportunity and the context under which implementation of a shared management solution would be possible.

While interim measures are important, ultimately elimination of the threat of transmission of bovine tuberculosis and brucellosis over the long-term is necessary. While reduction and elimination of these bovine diseases in the Wood Buffalo National Park metapopulation through depopulation and repopulation has been deemed technically feasible (Shury et al. 2006) at a substantial cost over many years, there is little support amongst local communities for the depopulation of the Wood Buffalo National Park metapopulation as a method for managing disease (Will 2015). Indigenous and non-Indigenous community members generally support the presence of Wood Bison in Wood Buffalo National Park, but would prefer that these animals were disease-free (Will 2015). Because Wood Buffalo National Park, where bovine brucellosis and tuberculosis are present, is the most genetically diverse Wood Bison local population, elimination of disease must conserve this genetic diversity. At present, the only effective tool for the elimination of the threat of bovine brucellosis and tuberculosis from Wood Buffalo National Park is the depopulation of the Wood Bison in the area. However, this may not be a desired

action for a number of reasons, including: public acceptance; the cultural connection between Indigenous groups in the area and these bison; the potential negative impacts on the Wood Buffalo National Park ecosystem; and the value of the Wood Buffalo National Park Wood Bison to species recovery as the most genetically variable Wood Bison population and the only bison population in the world that has existed in a location where they have always experienced wolf predation (although wolves were managed in Wood Buffalo National Park through poisoning and trapping from 1935 to the 1970s (Carbyn et al. 1993).

A new assessment of the practicality of alternatives to eliminate the threat of disease transmission, including recent advances in genetic salvage and long-term potential for the development of effective vaccines and improved diagnostic tests for bovine diseases, is required. A multi-stakeholder collaborative planning committee is being established to evaluate options to eliminate the risk of transmission of bovine brucellosis and tuberculosis from wild bison.

Maintain at least 90% of the genetic diversity, as measured by allelic diversity, within the Wood Bison subspecies and local recovery populations for the next 200 years.

McFarlane et al. (2006) reported that population size is the primary factor affecting loss of genetic diversity and populations need to be maintained above a minimum population size (*i.e.* $\geq 400 - 500$ individuals) to minimize the reduction of heterozygosity[10], which is a measure of genetic diversity. Modeling work suggests that a population size of 1,000 bison is required to achieve a 90% probability of retaining 90% of allelic diversity for 200 years (Gross and Wang 2005). Like most species, the effective population size in bison is much smaller than the actual size, due to past bottlenecks and inequality in number of breeding males and females (Hedrick 2009). Because the Wood Buffalo National Park local population is the most genetically diverse Wood Bison local population (McFarlane et al. 2006), it represents an important genetic heritage and resource for Wood Bison conservation and recovery.

Options to address the threat of loss of genetic diversity include movement of disease-free animals of known genetic background among local populations (Gross and Wang 2005), implementing selective breeding in recovery local populations (Wilson et al. 2005), establishing preservation and artificial breeding programs to maintain genetic diversity, and carefully managing local population reductions. Genetic diversity in reintroduced Wood Bison local populations could be improved by augmenting them with disease-free genetic material from the most genetically diverse stock in Wood Buffalo National Park or the Slave River Lowlands. A method for application of advanced reproductive techniques to Wood Bison is being developed that could allow the transfer of genetic material without the risk of disease transfer (Palomino et al. 2016, Cervantes et al. 2017, a, b). This approach could also be used to transfer genetic material from more heavily managed or captive populations to wild populations, where appropriate.

There is value in maintaining publicly managed local conservation populations that may be outside of the traditional Wood Bison range, such as the Elk Island National Park local population, to assist in achieving the short- and long-term objectives of the Wood Bison

[10] Heterozygosity is the expected probability that the maternal and paternal copies of genetic material are different for a given region of the genome.

Recovery Strategy. Recommendations have been outlined in Wilson and Zittlau (2004) that will assist land managers in maintaining genetic diversity within these local conservation populations.

Increase potential for connectivity among isolated local free-ranging, disease-free populations, and for population expansions (after the risk of brucellosis and tuberculosis transmission has been eliminated).

While increasing potential for connectivity among isolated local free-ranging, disease-free populations, and for population expansions, is important, it is not as important as containing and preventing the spread of bovine tuberculosis and brucellosis from Wood Bison local populations with diseases to disease-free local populations (the first broad strategy in Table 5). As such, the strategies below should only be undertaken in locations or at a time where they will not increase the risk of disease transmission from diseased to disease-free local populations of bison.

A number of Wood Bison local populations have stabilized at a smaller size than required to meet the long-term population and distribution objectives, and are in relatively close proximity to other Wood Bison local populations. Determining the factors explaining why local populations are not increasing in size or expanding their range will allow the development of plans to facilitate population growth and/or range expansion for local populations that do not currently meet the long-term objective of connected populations of at least 1,000 animals, in areas where this is deemed suitable and acceptable.

Currently, the total amount of suitable habitat available for Wood Bison recovery is unknown. Identification of potential areas for reintroductions will be an important step for future recovery of Wood Bison to ensure that disease-free, genetically diverse, connected, self-sustaining, free-ranging local populations can be distributed throughout their original Canadian range. The habitat limits for all local populations should also be examined, as this will help direct management decisions for maintaining local population sizes in line with the population and distribution objectives. While variables such as habitat type are important, habitat supply modelling should also take into account stochastic factors such as wildfires and climate change on habitat availability. Modification of habitat is a valuable management tool to improve habitat conditions and may be accomplished through such activities as fire management or industrial/agricultural practices.

A large area of the Wood Bison's original range is occupied by infected or disease-exposed bison, which limits the amount of habitat available to establish or expand disease-free recovery local populations, and the ability to have connectivity between currently diseased and disease-free local populations. The containment of these diseases in the short-term and elimination of the risk of transmission in the long-term is an important step to increase the area available for additional healthy local populations and support the population and distribution objectives.

The continued inventory and monitoring of demographics and disease status of all Wood Bison local populations is a necessary component of the recovery program, as it will assist with evaluating and determining when population and distribution objectives have been attained. Population and genetic modelling through population viability analyses will help determine persistence levels of local populations under current conditions, assess limiting factors, and evaluate the importance of different management scenarios.

Address and reduce additional important key threats to Wood Bison and their habitat.

Other threats that will need to be removed or reduced to meet the population and distribution objectives include accidental mortality via land and water traffic (Threat 4), hybridization (Threat 8.3), habitat loss and degradation (Threats 7.2, 11, 8.1), and predation (Threat 8.2).

A number of management options exist that may reduce road mortality including: high visibility collars on bison, enforcement of lower speed limits, improved signage, modifications to road salting policies, aversive conditioning (where unpleasant stimuli are applied to unwanted behaviour, such as using loud noises to scare bison away from roads), modification of the habitat adjacent to the highway to deter bison or create more suitable habitat away from the highway with prescribed burning, and intercept baiting with salt or high quality feed (Yukon Renewable Resources 1998, Rowe 2006, 2007, B.C. Bison and Roads Workshop 2007, Fort Nelson First Nation 2015). Development of new roadways for industrial access into Wood Bison ranges should consider the potential impacts of these roadways on bison movement.

Policies, regulations, and guidelines need to be developed and implemented to maintain genetic integrity and prevent hybridization between Plains and Wood Bison in the wild, and the mixing of domestic bison and cattle with free-ranging recovery local populations of Wood Bison. The British Columbia Bison Management Area (Figure 3) has been established to limit the distribution of Plains Bison and to exclude domestic bison. However, existing policies, regulations, and enforcement in this area are inadequate to prevent mixing of domestic bison and free-ranging Wood Bison (Harper et al. 2000). Policies, regulations, and guidelines must also be implemented to ensure that Wood Bison habitat is protected, as mentioned in the Population and Distribution objectives.

Changes to the hydrological cycle in the Lower Peace River, the Peace-Athabasca Delta, and the Slave River Lowlands have been observed (Appendix 1, Peters and Prowse 2001, Prowse and Conly 2002). The impacts of these changes on bison habitat should be quantified, and management actions such as modifying the flow from the W.A.C. Bennett dam should be examined to ensure that the bison habitat quality does not continue to decline in these areas.

Changes to the hydrological cycle may also be impacting the spread of invasive thistle in the Wood Buffalo National Park region. Spread of invasive thistle could be limited by implementing early detection and rapid response methods (Mikisew Cree First Nation 2015). Canada Thistle is classified as a noxious weed in Alberta and an integrated management plan with a variety of control options will likely be most effective as a long-term elimination strategy, given that killing the extensive root system is the only effective control method (Alberta Invasive Species Council 2014). Maintaining healthy native plant cover and rapidly reseeding disturbed areas can help to prevent establishment (Alberta Invasive Species Council 2014). Habitats may also be improved for bison by augmenting native grass populations (Appendix 1).

In harsh winters with heavy snowfall, starvation-related deaths have occurred in the Hay Zama herd (Government of Alberta 2013). The possibility of local community members being contracted to provide supplemental food to reduce starvation-related deaths could be considered in instances where heavy snowfall or large amounts of ice have occurred (Beaver First Nation 2015). Ascertaining contaminant levels in Wood Bison residing near industrial areas would allow

assessment of present levels and a basis upon which to monitor for changes to determine any potential for risk to the animals and those who consume them (Beaver First Nation 2015).

In parts of the Wood Bison range where anthropogenic disturbance is common, it is possible that wolves are moving more readily into areas, and are more able to successfully hunt Wood Bison by using the linear features as travel corridors (Appendix 1). The impact of linear disturbance on Wood Bison depredation should be examined and, if there is a negative relationship between wolf predation on Wood Bison and linear features, attempts should be made to restore linear features so that they cannot be used as travel corridors for wolves.

Increase public awareness and acceptance for Wood Bison, including acknowledging and augmenting social, cultural, ecological, and economic relationships among Wood Bison and Indigenous peoples and local communities.

To successfully re-establish and recover Wood Bison in parts of their original range, it is necessary to address and increase awareness of social, cultural, ecological, and economic issues of Indigenous peoples and local communities. Long-term sustainability of Wood Bison conservation efforts will largely be dependent on the cultural, social, and economic value these conservation populations bring to local communities and Indigenous peoples (see for e.g. Clark et al. 2016). In many areas throughout the range of Wood Bison, experience has shown that the perspectives, support, and engagement of local and Indigenous communities will have a significant influence on the outcome of long-term management objectives. Developing educational material to inform the public about the benefits of having bison on the landscape should increase public acceptance of Wood Bison recovery. Note that many activities to address this limiting factor are already underway (Section 6.1).

7 Critical Habitat

7.1 Identification of the Species' Critical Habitat

Critical habitat is defined in the *Species at Risk Act* (SARA) section 2(1) as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". Section 41 (1)(c) of SARA requires that recovery strategies include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction.

Critical habitat for the Wood Bison cannot be identified at this time due to insufficient information regarding range and habitat usage. Although each local population has similar general needs (Section 3.3), the specific habitat and land use patterns differ between local populations, often dramatically, due to regional differences in landscape characteristics, bison behaviour, and climate. Given the unique land use patterns of each local population, information will need to be acquired for each one. The general annual range of most herds is known (Figure 3); however, the specific regions within these ranges that are critical to survival and recovery are presently unknown. Furthermore, the minimum amount of habitat that is critical to support the targeted number of individuals is also unknown for each local population as most

local populations are presently not habitat-limited, excluding limitations of their range by control measures or agricultural/industrial activity.

One approach to identify Wood Bison critical habitat is to use resource selection function (RSF) models to determine important habitat variables and delineate suitable habitats (Jensen 2005a, b); thereafter, the amount of habitat required to support population and distribution objectives can be identified. Critical habitat can also be identified through other means, such as identifying important areas within local population ranges based on use by Wood Bison. The identification of critical habitat can consider graminoid prevalence, winter foraging habitat (with forage biomass being an important component), connectivity (including mean inter-patch distance and patch size), habitat use based on occurrence data, standing crop biomass, and species composition. It is important that the method used to identify critical habitat takes into account the scale-dependency of Wood Bison habitat use. Suitable habitat patches may occur within a larger matrix of less desirable locations. The appropriate method for the identification of critical habitat for each local population will be determined through completion of the Schedule of Studies.

A schedule of studies is presented in section 7.2 for identification of critical habitat (Table 6).

7.2 Schedule of Studies to Identify Critical Habitat

Critical habitat will be fully identified for all free-ranging disease-free local populations within the original Canadian range of Wood Bison (Figure 2) following completion of the schedule of studies (Table 6). The Chitek Lake local population is not included herein because it lies outside the original range of Wood Bison. Disease status is as listed in Table 3. Indigenous Knowledge and contributions from Indigenous and other local persons that help to identify critical habitat will be included where possible/available. Many Indigenous communities contributed extensive knowledge during community consultations in 2015 or prior (Appendix 1) that will inform the critical habitat identification for bison herd(s) in their traditional territory. Critical habitat will be identified for diseased local populations once population and distribution objectives are developed as presented in section 5.

Table 6. Schedule of Studies to Identify Critical Habitat

Description of Activity	Rationale	Timeline
Collect and analyse existing occurrence data (e.g., telemetry, aerial surveys, local observations) for Wood Bison. Where necessary, conduct additional western science and Indigenous knowledge studies to refine knowledge on existing distribution and occupancy.	Areas used by Wood Bison in all free-ranging disease-free local populations are determined.	2018-2021
Obtain data and knowledge on habitat use and suitability, including Indigenous knowledge.	Resources and predictors of use are identified.	2018-2021
Perform conductivity analysis to determine areas that can be used for interpopulation movement.	Movement corridors that allow populations to become connected are identified.	2019-2020
Identification and assembly of comprehensive habitat layers as required for the development of a predictive habitat model	Comprehensive habitat layers are identified and assembled	2018-2019
Develop and apply a predictive habitat model for species recovery for all disease-free local populations, where appropriate.	Predictive habitat model applied in all disease-free local populations, where appropriate.	2019-2023
Evaluate range composition and carrying capacity. Determine the amount and spatial distribution of habitat types required within the range, where appropriate.	Type, quality, amount, and spatial distribution of habitat components are specified and critical habitat is identified.	2018-2023

8 Measuring Progress

The performance indicators presented below provide a way to define and measure progress towards achieving the population and distribution objectives.

- Disease-free status, local population size, and range of all disease-free local populations within the original range will be maintained in cases where local populations are self-sustaining.
- Local population size and/or range are increased to allow for self-sustaining status to be achieved for disease-free local populations that are not currently self-sustaining.
- Extralimital and captive local populations managed for conservation are maintained.
- Genetic diversity is maintained or increased in all local populations.
- At least five disease-free, genetically diverse, self-sustaining, free-ranging Wood Bison populations exist, distributed across their original Canadian range, with a minimum size for each population of 1,000 animals.
- Bovine brucellosis and tuberculosis within Wood Buffalo National Park will be contained over the short term, and the threats from these diseases will be eliminated in the long-term.
- Connectivity and gene flow among Wood Bison populations occur after threats resulting from the presence of bovine diseases have been eliminated, where appropriate.

9 Statement on Action Plans

One or more action plans will be completed for Wood Bison by 2022.

Action plans may be developed for Wood Bison local populations and not necessarily by jurisdiction. The Minister of Environment and Climate Change may adopt or incorporate parts of an existing provincial or territorial plan, or other relevant planning documents that meet the requirements of SARA as an action plan. Local community involvement and engagement in the development of each of these local population-based documents will be critical for the successful recovery of Wood Bison.

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Appendix 1: Métis and First Nations Contribution Summary

In 2015, Environment and Climate Change Canada engaged with First Nations and Métis communities within the present range of Wood Bison in Canada. Following is a list of contributors whose knowledge and input was invaluable in shaping this recovery strategy.

The unpublished meeting summaries and correspondence comprise the following meetings/documents:

Acho Dene Koe First Nation. (April 29, 2015). Email to Environment Canada Re: Wood Bison Recovery Strategy under the federal Species at Risk Act.

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Fort Nelson First Nation. (June 23, 2015). Letter to Environment Canada regarding the Draft Recovery Strategy for Wood Bison in Canada. Fort Nelson, BC.

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Métis Nation of British Columbia. (March 17, 2015). Letter to Environment Canada re: *Recovery Strategy for the Wood Bison (*Bison bison athabascae*) in Canada.* Abbotsford, BC.

Mikisew Cree First Nation. (February 25, 2015). *Summary of Community Meeting with Environment Canada for Wood Bison Recovery Strategy Development*. Canadian Wildlife Service unpublished report. Fort Chipewyan, AB.

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Smith's Landing First Nation. (May 20, 2015). *Questionnaire Response to Environment Canada for Wood Bison Recovery Strategy Development*, NT.

West Point First Nation. (July 23, 2015). *Summary of Community Meeting with Environment Canada for Wood Bison Recovery Strategy Development*. Canadian Wildlife Service unpublished report. NT.

Appendix 2: Summary of the History of Disease Management in Wood Buffalo National Park

Year	Event
1922	Wood Buffalo National Park (WBNP) established.
1926	Introduction of Plains Bison to WBNP. The Plains Bison are believed to have brought bovine tuberculosis and brucellosis to the park.
1954-62	Bison Management Program was implemented with the goal of reducing prevalence of disease, mainly tuberculosis. The program ceased in 1962 due to public criticism and lack of acceptance.
1968	Management proposal for WBNP. Proposed using enclosures to contain animals and slaughter animals that tested positive for bovine tuberculosis or brucellosis. This test and slaughter proposal was rejected due to cost and perceived criticism of slaughter.
1972 - 1977	WBNP Management Programs initiated and included construction of corrals to increase vaccination rate for anthrax. Round-ups terminated in 1977 due to high cost, difficulty in capturing animals, short-term nature of vaccine, harassment and stress to bison, and public criticism.
1986	An interjurisdictional steering committee to review and evaluate management options created a Disease Task Force.
1988	The Disease Task Force Report was completed. It evaluated bovine tuberculosis and brucellosis in bison in Northern Canada and options for dealing with the issue. The bison disease issue was referred to a federal Environmental Assessment Panel (EAP) to recommend a solution and assess its impact on environment, resource conservation, people, and the local economy.
1990	EAP Report recommended depopulation and repopulation with disease-free Wood Bison (Federal Environmental Assessment and Review Process 1990). There was strong opposition to this recommendation from the public including First Nations.
1991	The Northern Buffalo Management Board (NBMB) was established (including representatives from native communities and Department of Indian Affairs and Northern Development to develop a management plan for eradication of bovine tuberculosis and brucellosis in and around WBNP.
1992	The Northern Buffalo Management Report was submitted to the federal government identifying significant knowledge gaps that needed to be addressed and a request for significant additional funding.
1995	A 5-year Bison Research Containment Program (BRCP) was established in response to EAP and NBMB. The objective was to contain diseases and to establish a basis for management decision-making grounded in science, traditional knowledge, and consensus. Development of Research Advisory Committee (RAC). A research program on bison ecology and the effects of predators, disease, and habitat change on the population dynamics of Wood Bison in WBNP was initiated.
2001	BRCP Final Report recommended a 4-year extension because of the complex issue and requested significant additional funding. The request was denied and the RAC was terminated.
2003	Interim Measures Working Group was established, consisting of agencies from Canada, Alberta and NT. Purpose was to examine establishing control zones in northern Alberta on the west side of WBNP to contain and manage diseases. This initiative was deferred in favour of recommending that a long-term strategy for disease risk management be developed.
2005	The Disease Task Group of the Canadian Wildlife Directors' Committee (CWDC) was established to take the lead and develop a strategic path forward for conservation and recovery of Canada's threatened Wood Bison local populations, based on the concern that the likelihood of successful recovery is reduced until the disease issue is adequately addressed. The group consists of Parks Canada Agency, Alberta, NT, and the Canadian Wildlife Service.
2005	A Bison Disease Technical Workshop was held to assess the technical feasibility of eliminating bovine tuberculosis and brucellosis from free-roaming local populations of bison in the WBNP area through depopulation and subsequent repopulation (Shury et al. 2006). The conclusion was that it is technically feasible, but at a very high cost over 10-20 years.

Appendix 3: Genetic History of Current Wood Bison Local Populations in Canada

For a full review of the translocation history, please see Gates et al. (2001).

Wood Bison local population	Province/ Territory	Year of founding(s)	Number of founders	Source of founders
Mackenzie	NT	1963	16	WBNP
Elk Island National Park (EINP)	AB	1970	11[1]	WBNP
Nahanni[2]	BC,NT,YT	1980, 1989, 1998	99	EINP, Moose Jaw Wild Animal Park[3]
Aishihik	YT	1988-1992	142	EINP, Toronto Zoo, Moose Jaw Wild Animal Park[3]
Hay Zama	AB	1984	29	EINP, Banff National Park[3]
Nordquist/Liard	BC,YT	1995	49	EINP
Etthithun	BC	1999	19	EINP
Chitek Lake	MB	1991, 1996	22	EINP
Slave River Lowlands*	NT	–	200[4]	–
Wood Buffalo National Park* (WBNP)	AB, NT	–	250[5]	–
Wentzel Lake*, Wabasca, Ronald Lake	AB	–	n/a[6]	–

[1] Parent founder herd of 23 animals, released in 1965 and 1967, destroyed because of disease. 11 calves salvaged at birth and hand-reared (Gates et al. 2001b).

[2] A total of 99 individuals were introduced into the Nahanni herd over three founding events to the same location in northern BC. The population subsequently expanded into NT and YT.

[3] The Moose Jaw Wild Animal Park, Toronto Zoo, and Banff National Park populations were all established from EINP animals. The Moose Jaw Wild Animals Park and Banff National Park populations no longer exist.

[4] For this local population, "founders" refers to the lowest number of animals estimated, which was 200 in 1949 (Fuller 1950).

[5] For this local population, "founders" refers to the lowest number of animals in region estimated around 1900s (Soper 1941).

[6] These populations are thought to be associated with Wood Buffalo National Park. They were not established through human actions.

*Populations are affected by bovine tuberculosis and brucellosis.

Appendix 4: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[11]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[12] (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

It is anticipated that the activities identified in this recovery strategy will benefit several species and the environment. In particular, the conservation and reintroduction of Wood Bison could have a positive impact on large carnivores through the addition of another prey species in the ecosystem. If Wood Bison populations are removed or lost, then co-evolved predators, such as wolves, will be negatively affected. Local populations of two predatory species classified as Special Concern by COSEWIC, the Grizzly Bear (*Ursus arctos*) and Wolverine (*Gulo gulo*), may benefit from Wood Bison recovery. Other species that prefer sedge habitats such as the Yellow Rail (*Coturnicops noveboracensis*, listed as a species of Special Concern under SARA) may benefit from habitat protection or enhancement for Wood Bison. However, the Baikal Sedge (*Carex sabulosa*, listed as Threatened under SARA) may be negatively affected by trampling if bison herds expand into the Alsek Dunes in Kluane National Park and Reserve, one of the locations where the species grows. Management strategies should strive to benefit all target species and minimize negative effects on other native species. Efforts should be coordinated across species to help ensure the most efficient use of resources, and to prevent duplication of effort and management conflicts.

It has been suggested that the reintroduction of Wood Bison to areas where they have been absent for many decades may have implications to existing wildlife, specifically populations of Moose (*Alces alces*) and Woodland Caribou (*Rangifer tarandus*), species with which local people have long-established cultural relationships (Appendix 1). However, Wood Bison that have been present in habitats for long periods, such as in Wood Buffalo National Park and Elk Island National Park, appear to coexist with Moose without detriment to either species. The Wood Bison in the introduced Aishihik herd in Yukon Territory do not appear to displace Moose or caribou in winter (Jung et al. 2015a, Jung et al. 2015b). Bison diets are primarily comprised of grasses and sedges, while Moose forage primarily on woody browse; thus competition for forage between these two species is likely low (Waggoner and Hinkes 1986, Reynolds et al. 2003).

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[11] www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1

[12] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

Wood Bison and Woodland Caribou select different habitats with little overlap in diet composition (Fischer and Gates 2005). In the Mackenzie population, Larter and Gates (1991) found a high percentage of lichens in the fall diet of Wood Bison, suggesting there may be forage competition with Woodland Caribou, although this was found to occur only during the fall season. However, Wood Bison may also have an indirect negative impact on caribou and other ungulates by acting as an alternate prey species, which results in an increase in wolf numbers (Larter et al. 1994, Jung 2011, Species at Risk Committee 2016). Habitat alterations undertaken to improve Wood Bison population connectivity such as controlled burns or linear features should consider impacts to Woodland Caribou habitat. Additional studies are needed for information on the effects of newly reintroduced Wood Bison on other species in a variety of habitats and across seasons.